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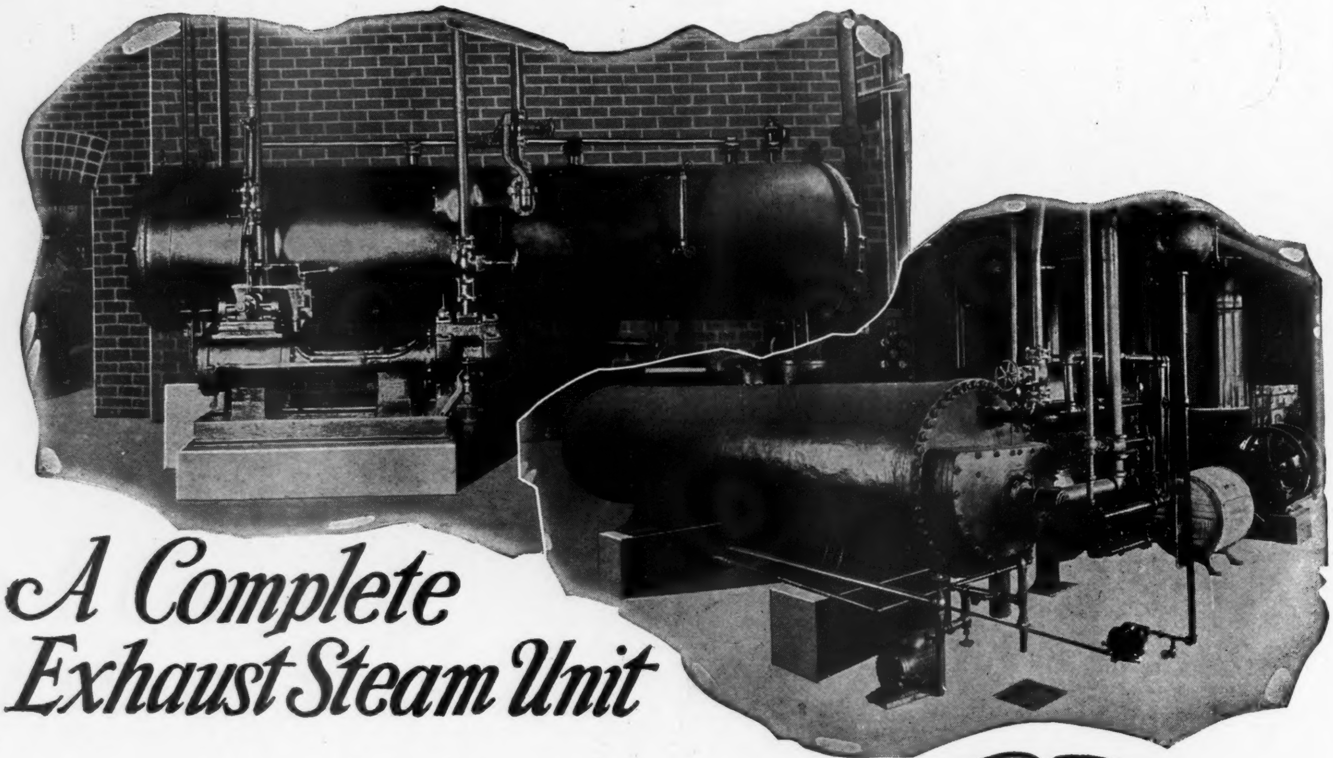

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VOL. XXVIII, NO. V

MAY, 1923

Compressed Air's Part in Municipal Rapid Transit

How Travel is Controlled and Safeguarded in Subways, Tubes and Elevated Railway Lines of the Interborough Rapid Transit Company of New York City

By RICHARD HOADLEY TINGLEY

THE carriage of more than 1,000,000,000 people in the course of a year with an insignificant number of interruptions to service is a transportation performance of outstanding excellence. Such is the achievement of the Interborough Rapid Transit System of New York City.

The present article tells of some of the manifold facilities that make a record of this sort possible; and in this recital is disclosed how large a part compressed air plays in speeding train movement, in making for operative smoothness, and in safeguarding the traveling public at every stage of the journey.

It would be unsafe, in fact impracticable, to run either the subway or the elevated trains at their present speeds and with their frequency if the switching and the signal systems were not of a highly efficient and dependable character. To this end compressed air and electricity are so ingeniously combined in service that the traffic can be regulated like clock work.

AS WE travel swiftly and safely over the intricate track systems of our big railroad terminals or are shunted at high speed through subways or tubes and over elevated structures, we take it as a matter of course that we shall reach our destination without jar or mishap. We pay but little heed to the factors that make for our safety, our rapidity of motion, and our comfort; yet behind it all are instrumentalities each specialized to perform some particular function which contributes to this smooth operation that means so much to us.

The development of modern rapid transit is the product of less than a generation. The part played in it by compressed air is still younger, and is of more importance than the average layman knows—indeed, it may truly be said that, without its assistance, rapid transit would be impossible. Without it, also, many of the less important though necessary functions of railroad operation and maintenance would have to be performed in the tedious and uneconomical ways of other days.

It is to describe some of these uses of compressed air that this article is written; and the rapid-transit systems of New York City, particularly the Interborough Rapid Transit with its subways, tubes, and elevated lines carrying more than 1,000,000,000 people a year, is taken by way of illustration, for here the art and the development of the uses of air have reached, perhaps, as high a degree of perfection as anywhere in the world of transportation.

The Interborough takes its power from two immense prime-mover stations. These power houses send out current at from 11,000 to 19,000 volts, A. C., to substations, where it is transformed to lower D. C. voltages suitable for the varied services it has to perform.

One of the largest uses of compressed air is in the drainage and ventilating system of the subways and tubes. With track and station platforms below the sewer level, constant pumping of drainage water is necessary; and a free movement of fresh air must at all times be maintained. Large quantities of compressed air are also continually employed for train control through an intricate system of substations, for interlocking stations, and for the electro-pneumatic working of signals and switches, without which there could be no real rapid transit.

Air performs other necessary functions for the Interborough. In track work it tamps the ties, assuring a more uniformly surfaced roadbed than could be obtained by hand tamping. The economy of pneumatic tamping, too, is now fully recognized, as it is practicable for two men to tamp as much track in a day with pneumatic tampers as eight men could do using hand tamping bars or picks.

Compressed air, with the aid of pneumatic tools, now does the track drilling for tie rods, bond wires, and bolts, as well as the running on and backing off of bolt nuts, formerly tediously done by hand; and air jets are used in cleaning machinery of all kinds. The Interborough has three large machine shops fully air equipped for the operation of pneumatic tools, hoists, elevators, cranes, and special machines, without which a machine shop would, in the modern sense, cease to be a machine shop.

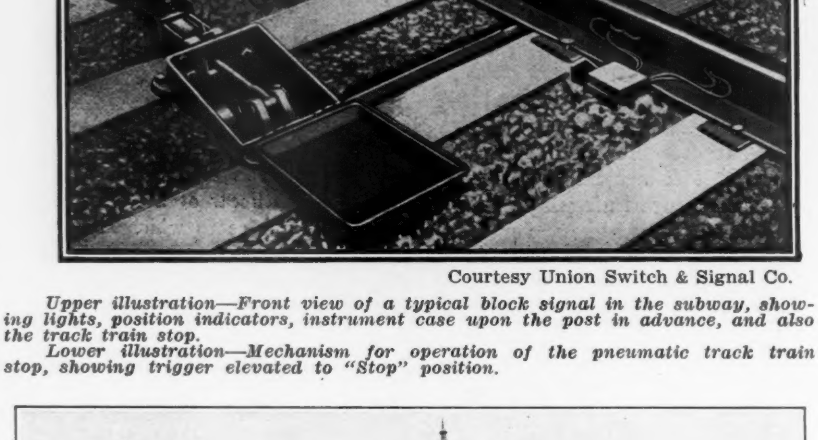
Formerly, all subway trains were controlled by the "straight air system." For the past twelve or fifteen years, however, train braking operations have been under electro-pneumatic control—the air being supplied by an electro-driven compressor on each car of a train. Another useful service to which air has been put is in the automatic electro-pneumatic working of platform extensions at stations on sharp curves. These curves leave awkward and dangerous spaces at the center doors of cars—spaces which are filled, as soon as the train stops, by a sliding extension to the platform.

The control of doors of subway cars has recently been much improved. Prior to last year one gateman controlled the opening and the closing of the doors of two cars by two separate operations—one, mechanical, unlocking the doors held by a trip at the bottom and back, the other, releasing the air which moved the doors. The improved installation does away with the mechanical release—combining the two operations in one which is electro-pneumatically controlled by a single gateman for all the doors of two cars.

For reasons of economy, the compressors for some of the services mentioned are located in the various substations along the subway routes. In these substations, where the electric current is stepped down from 11,000 and 19,000

Courtesy Union Switch & Signal Co.

Upper illustration—Front view of a typical block signal in the subway, showing lights, position indicators, instrument case upon the post in advance, and also the track train stop.
Lower illustration—Mechanism for operation of the pneumatic track train stop, showing trigger elevated to "Stop" position.



An example of complicated switching and signaling equipment required at points in the Interborough Rapid Transit System.

volts A. C. to 600 volts D. C. for use in car propulsion, are usually located two compressors, each of 1,000 cubic feet capacity. The air is distributed from these compressors through one or two 6-inch pipes, as the case may be, laid in the street from the substation to the subway structure.

At the points where the 6-inch air lines enter the subway are located distributing headers and water and oil separators. The purpose of the distributing headers is to send the air in whatever direction it is wanted, or to provide a means of by-passing any compressor unit in case of breakdown. The arrangement of the compressor units and headers is such that any compressor on any line, provided it has capacity enough, can supply any portion of the subway. The compressors are set to cut in at 75 pounds and out at 85 pounds. The pressure on the main line in the subway is from 65 to 75 pounds. The pressure at the compressors in the substations and at other points is from 75 to 85 pounds.

The subways, except for a short stretch, are completely equipped with a 3-inch air line, approximately 300,000 feet in length. The air carried by these pipes is used for operating the track drainage pumps, the station toilet ejectors, the automatic switchboards of the ventilating system, and the track tamping machines; and connections are made at frequent intervals with the air line in order that pneumatic machines, such as "Jackhamers," drills, etc., may be used from time to time for subway work.

There are about 28,000 feet of pipe lines of other sizes which are required for distributing air. The eleven compressor stations of this branch of the service are of the following capacities:

3 stations with 1,000 cu. ft. of free air per min.
5 stations with 2,000 cu. ft. of free air per min.
1 station with 1,600 cu. ft. of free air per min.
1 station with 230 cu. ft. of free air per min.
1 station with 500 cu. ft. of free air per min.

The majority of the pumps for track drainage are steam pumps actuated by compressed air; and their capacities range from $12\frac{1}{2}$ gallons to 1,000 gallons per minute. Station toilet ejectors are of a special Interborough design, and are operated entirely by compressed air. The ventilating system is of the distance-control, automatic type; and compressed air is used to shift the dampers in the various flues and also to throw in the circuit breakers which control the main current to the fan motors.

There are six under-river, tunnel-ventilating, blower plants and 26 subway ventilating plants. The air is admitted to circuit-breaker air cylinders and to the damper air cylinders by means of an electro-pneumatic valve. The control board operates the magnet on the electro-pneumatic valve, and by raising the latter it permits air to enter the cylinders accordingly as their switches are thrown at the control board.

All of the air pumps and the ejectors in the subway are started or stopped automatically by the water level. In the working of the air pumps a pilot valve is connected with a ball float rigidly attached to a rod. As the float rises with the water level, this tips the pilot valve, which permits air to enter a cylinder at

the top of the governing valve on the pump. The movement of the cylinder, receiving the air from the pilot valve, lifts the governing valve of the pump so that air is admitted to the steam chest of the pump and thus causes it to run. When the water again drops to a predetermined level, the pilot valve is closed by the weight of the float and the pump stops.

A typical track-drainage pump room will serve as an example of many similar installations with which the subway is provided. It is equipped with one electric triplex pump, one 16x12x18-inch Cameron, air-driven steam pump, and one 4-A Cameron, air-driven steam pump. The air is delivered by a $2\frac{1}{2}$-inch line, which runs directly through the air inlet part of the steam chest of a 16x12x18 inch Cameron pump. A $\frac{3}{8}$-inch line taps the $2\frac{1}{2}$-inch air line for feeding the 4-A Cameron steam pump. The $2\frac{1}{2}$-inch air line is also tapped by a $\frac{1}{2}$-inch line leading to the pilot valve, which controls the functioning of the governing valve.

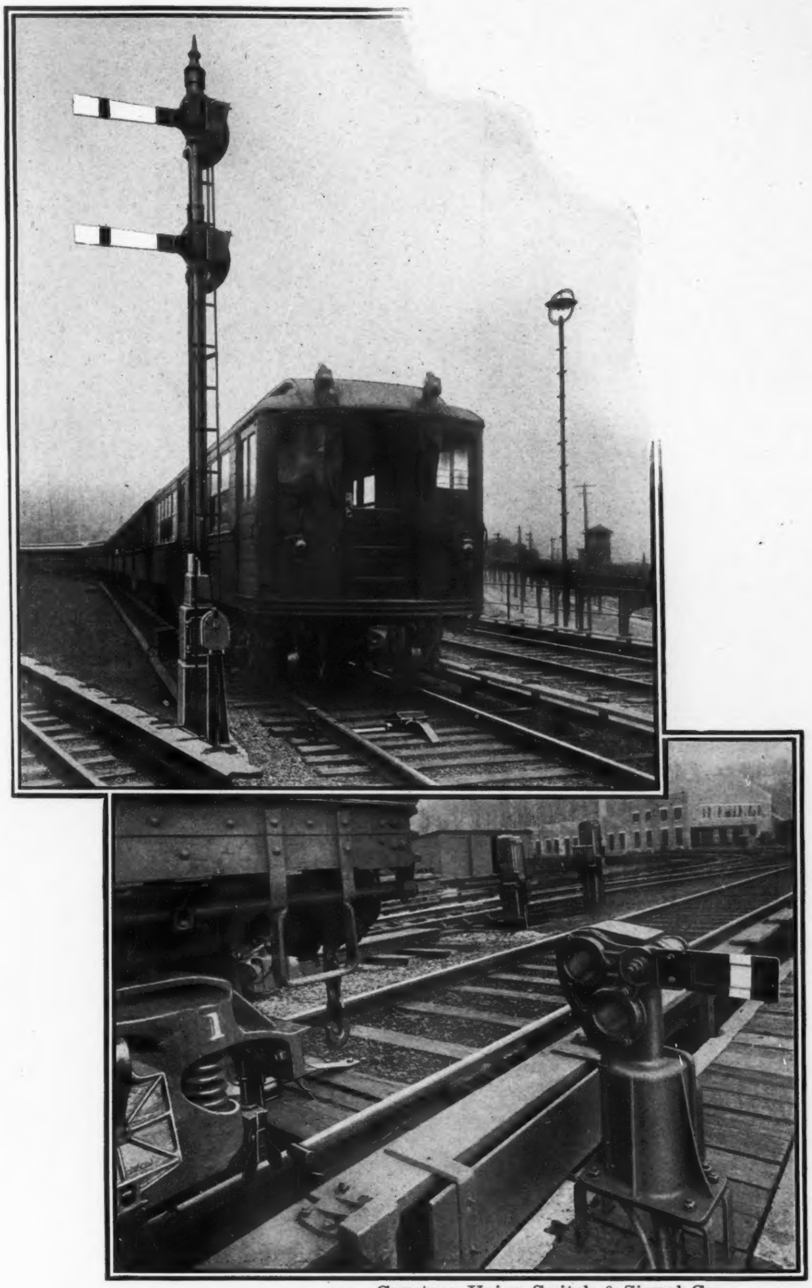
For the operation of air lifts, the air supply at each lift is controlled by a float which moves up and down with the water level in the sump. This float is connected by a system of levers to a butterfly valve in the air supply pipe leading from the main air line in the subway. This air is first carried through a reducing valve before entering the air lift. When air is admitted at the top of the air-lift head the air goes down between the inside and outside pipe to the bottom of the lift where it mixes with the water and causes the latter to be discharged into the sewer at a pressure of about 30 pounds.

Compressed air is also used to operate the circuit breakers which control the power on the third rail. The contact rail in the subway is sectionalized, so that in case of trouble in a part of the subway any particular section can be killed and still leave the current on the rest of the system; and feeding points are also provided at frequent intervals. These sections and feeding points are operated by remotely controlled circuit breakers by a system of electro-pneumatic valves and cylinders.

In developing the plans for the subway rapid-transit system it was foreseen that efficient operation under heavy traffic would depend largely upon the block signaling and interlocking systems adopted for facilitating the spacing of trains and the protection of train movements. The present system of train control, through the operation of electro-pneumatic signaling, switching, and interlocking devices, is the result of years of study on the part of the signal engineers of the Interborough. That a degree of operative excellence in electro-pneumatic signaling has been reached is evidenced by the following memorandum of performance for the year ending June 30, 1921:

In the number of signal failures the signal operations per failure, and the ratio of failure tabulated, the figures may be misleading in that many of the failures were probably on the side of safety. In other words, the signal or apparatus, in failing, showed danger instead of safety.

Each signal of the system is operated by a single-acting cylinder, to which air is admitted under the control of a pin valve and an electro-

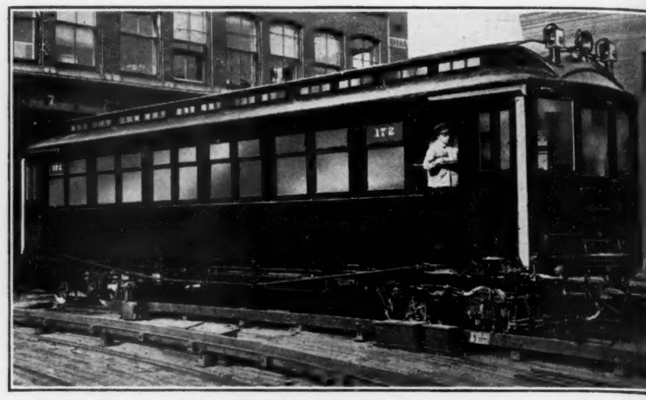


Courtesy Union Switch & Signal Co.

Upper illustration—Automatic stop mechanism in track at Van Cortlandt Park. Lower illustration—Dwarf signal and automatic train stop—Electro-pneumatic interlocking, at 228th Street Yard of the Interborough Rapid Transit.

Fort George tunnel on subway line south of Dyckman Street station.

No man is assigned to a responsible position anywhere in this great transportational system until he has received thorough schooling.



One of the 500 cars which have been recently fitted with pneumatically controlled end and side doors.

Electro-Pneumatic Signaling Record

	Subway	Elevated	Total
Total signal operations	235,559,967	89,003,861	324,563,828
Number of signal failures	593	235	838
Signal operations per failure	397,234	378,739	391,985
Ratio of failure	.0000025	.0000026	.0000026

magnet. Inasmuch as gravity is employed to return signals to their "stop" position, double-acting cylinders are not needed. The pin-valve magnet is connected by wire with its operating lever in the interlocking machine, and is energized only when the lever assumes one of its extreme reverse positions. When so energized, air is admitted to the cylinder and the signal moved to the "proceed" position. This movement opens a contact in a second circuit, including an electric lock engaging a signal lever, thereby applying the lock to prevent a complete return of the lever to its normal position. Its partial return, however, is permitted—a movement which causes the interruption of the signal circuit and hence a return of the signal to the "stop" position. Upon reaching the "stop" position the circuit, including the lever lock, is again established and the lock reënergized. This results in the release of the lever so that it may assume its normal position.

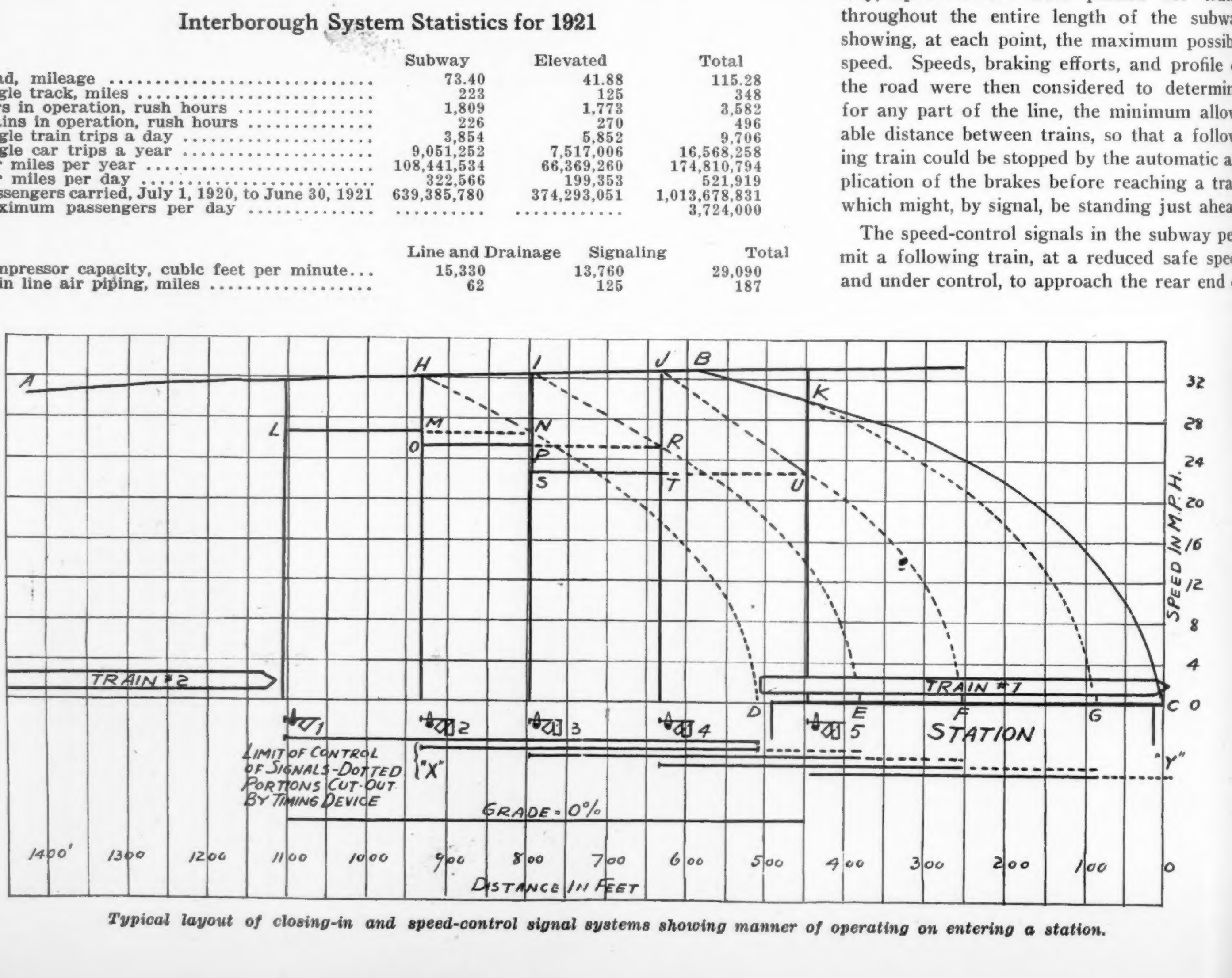
Interborough System Statistics for 1921

	Subway	Elevated	Total
Road, mileage	73.40	41.88	115.28
Single track, miles	223	125	348
Cars in operation, rush hours	1,809	1,773	3,582
Trains in operation, rush hours	226	270	496
Single train trips a day	3,854	5,852	9,706
Single car trips a year	9,051,252	7,517,006	16,568,258
Car miles per year	108,441,534	66,369,260	174,810,794
Car miles per day	322,566	199,353	521,919
Passengers carried, July 1, 1920, to June 30, 1921	639,385,780	374,293,051	1,013,678,831
Maximum passengers per day	....	....	3,724,000

	Line and Drainage	Signaling	Total
Compressor capacity, cubic feet per minute...	15,330	13,760	29,090
Main line air piping, miles	62	125	187

Long and careful tests were made and curves were computed by the Interborough engineers to determine the distance in which trains could be stopped at various rates of speed and on different grades up to 3 per cent. In this way, speed curves were plotted for trains throughout the entire length of the subway showing, at each point, the maximum possible speed. Speeds, braking efforts, and profile of the road were then considered to determine, for any part of the line, the minimum allowable distance between trains, so that a following train could be stopped by the automatic application of the brakes before reaching a train which might, by signal, be standing just ahead.

The speed-control signals in the subway permit a following train, at a reduced safe speed and under control, to approach the rear end of



Typical layout of closing-in and speed-control signal systems showing manner of operating on entering a station.

a train halted at a station, and allows the closing-in train to keep moving forward in safety as the station train starts away. Speed-control and automatic-train-stop devices are also utilized where sharp curves and steep grades are approached. By these various control apparatus, neighboring trains can move in unison and as near to one another as is practicably safe.

The control of switching operations is almost entirely electro-pneumatic. The switches, in electro-pneumatic interlocking, as in all approved power interlockings, are unlocked, operated, and again locked by one continuous operation of the prime mover, the cylinder. This device, as a whole, is a switch-and-lock movement, and includes a 4-inch compressed air cylinder having a stroke of twelve inches. Air is normally used at a pressure of 75 pounds; and the switch is thrown in either direction by three electro-pneumatic operations. The layman, looking along the track, sees only the little iron boxes at frequent intervals. Removing the cover of one of these, he will find an aggregation of magnets, valves, and cams—all connected with the electric wiring and the air distribution system of the line, each of which is primarily actuated, like the mechanism of the signal boxes, from the interlocking station.

Pneumatic tie tampers are used continuously to keep the subway track beds in proper condition.

To control the signaling and switching operations of the 348 miles of subway and elevated track there are 131 interlocking stations. Of these, 111 are of the electro-pneumatic type—twenty being equipped with the old mechanical method. Only one of the latter, however, is on the subway: the nineteen others being on the elevated. In the largest of the electro-pneumatic interlocking stations there are 107 levers in charge of two operators. Of these, 57 control the intricate arrangement of switches.

The air used in the signaling division of the system is independent of that employed in the other operations previously described, and is distributed through separate mains. The total length of such piping is approximately 125 miles. Signaling air is compressed, at many stations, by power taken from the third rail, and is cooled and dried before distribution. The capacity of these plants is 13,760 cubic feet per minute. Some idea of the magnitude of the interlocking system of the Interborough in switch and signal service may be had from the accompanying table:

The advantages of employing compressed air in combination with electricity in interlocking switching and signaling operations as against other means—such as the all-electric control— are many. But the curious will ask: Why, as long as electricity is an essential medium and is relied upon so completely for most of the duties of the system, is not its use extended to include the function now assigned to compressed air? The answer is: Gain in simplicity, accessibility, and durability incident to the adoption of the dual system. And there is the added advantage arising from the easy regulation of the compressed air, which latter induces no destructive action upon either the devices controlling it or upon the appliances utilizing it.

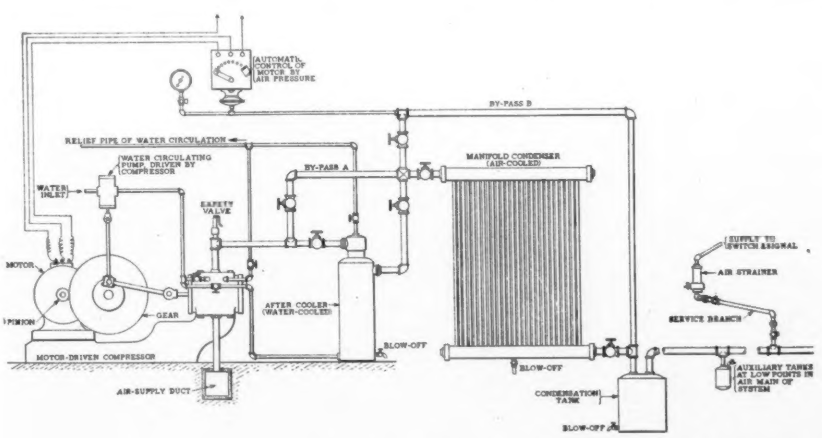
In the brief space available for the treatment of so large and comprehensive a subject it has been possible to touch upon only the main outstanding applications of compressed air in modern rapid transit. Did space permit, we might tell of the intensive uses to which the Interborough puts air in its three large machine and repair shops and how the foremen of these shops have turned to compressed air to perform many operations formerly done by electricity or by steam direct. But this matter, as Kipling says, is "another story."

The Bank of Iceland has had a quantity of silver 25-öre coins (at normal exchange 6.7 cents) struck off by the Royal Danish Mint. This is the first specie ever minted for that Arctic state, and is intended for home use only.

Interborough Interlocking System for 1921

	Subway	Elevated	Total
Number of levers in electro-pneumatic interlockings	1,343	626	1,969
Number of levers in mechanical interlockings......	32	255	287
Number of interlocking signals....................	1,575	737	2,312
Number of automatic signals	1,438	1,142	2,580
Number of track circuits.........................	2,158	1,006	3,164
Number of automatic stops........................	1,498	857	2,355
Number of switches and derails signal controlled..	650	325	975
Number of air compressors........................	60	24	84
Cubic feet per minute capacity of compressors.....	9,145	4,615	13,760

	Subway	Elevated	Total
Cost of maintenance of signal system, year ended June 30, 1921	$373,090	$195,647	$568,737
Cost of signal maintenance per car mile	$0.00344	$0.00294	$0.00319
Cost of signal maintenance per passenger........	$0.000583	$0.000523	$0.000553



Courtesy Union Switch & Signal Co.

Diagram of typical air compressing, cooling and distributing system for electro-pneumatic interlocking.

The cantaloup from an Arizona ranch, or the orange from a California grove, transported in a refrigerator car to Boston, for example, entails an expenditure of coal, in the form of ice and locomotive fuel, of from one-half pound to two pounds, depending on the season. So much for the part that coal, or its equivalent in oil or water power, plays in our daily dietary.

Despite the severe shipping depression, motorship tonnage—full-powered ships of 2,000 gross tons or over—increased 37 per cent. in the year ending June 30, 1922, as against a gain of but 4 per cent. in steam tonnage.

The United States is the largest manufacturer of rubber goods, and uses about 45 per cent. of the world's production of crude rubber. Some 32,000 articles are now made of rubber.

Laboratory Production of Liquid Air

The Removal of Impurities From the Air Before Its Liquefaction—Design and Construction of the Liquefier

By S. R. WINTERS

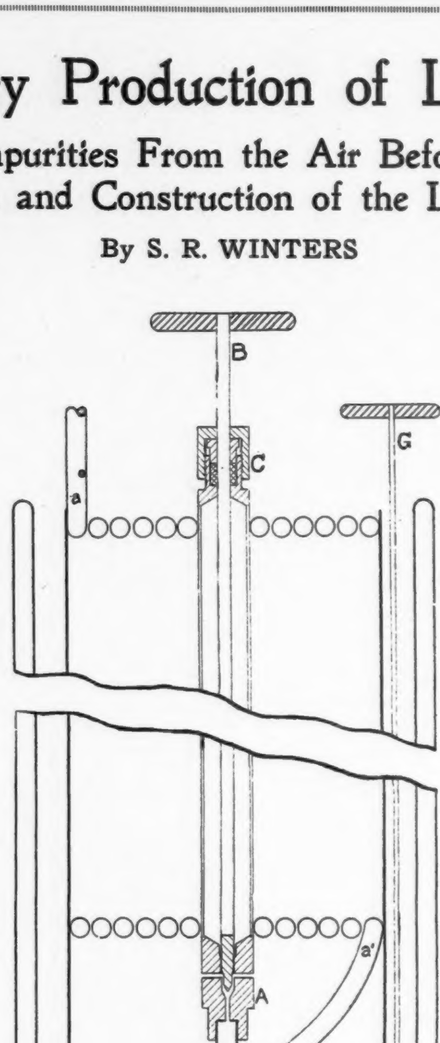
THREE AND ONE-HALF miles from the White House—in a squatty building nestled among the group of structures comprising the physical equipment of the Bureau of Standards, United States Department of Commerce—liquid air is being produced in a laboratory at a rate of three gallons an hour. The simple arrangement by which this product—ordinarily requiring pretentious commercial equipment—is now manufactured is a feature that lends distinctiveness to this miniature factory.

A 4-stage compressor, driven by a 35-H.P. steam engine, has a capacity of 75 cubic feet of free air a minute. The container for the sodium hydroxide solution employed in removing the carbon dioxide is eight feet long and 4½ inches in diameter. The impurities in the air in question are water and carbon dioxide, both of which would freeze solid in the liquefier.

The carbon dioxide is removed by allowing the air to bubble up through a solution of sodium hydroxide, more commonly known as "lye," contained in a vertical unit. Shattered marble is also used in the container to insure intimate contact and to act as a retarding force against the carrying over of spray. One gallon of a 25-per cent. solution of sodium hydroxide is admitted sufficient to half fill the container.

Water vapor is disposed of by means of three calcium chloride purifiers, each three feet long and two inches in diameter on the inside, operated in series. Stationed in a vertical position, the air enters each purifier successively from the bottom. The calcium chloride solution formed during the process is discharged through a drain located at the bottom of each tube. Five pounds of lump (anhydrous) calcium chloride are employed to fill the series of purifiers. Connections to the purifiers are effected by ball-and-socket unions of the design common to high-pressure gas cylinders.

The compressed air, of the required purity and at room temperature, is cooled to zero Centigrade by a circulation of calcium chloride brine cooled by an ammonia plant. Afterwards, the cooling continues from — 20° to 35°C. by a CO_2 cycle. The regenerator coil employed in this miniature liquid-air manufacturing plant consists of 200 feet of copper tubing of 3/16-inch outside diameter. It is completely closeted by a glass Dewar vessel, similar in construction to the common vacuum-jacketed food container or thermos. An automatic float delivery valve, with mechanical adjustment, is accessible—a convenience for holding the vessel open as needs may dictate. A needle valve has been found a serviceable unit. Laboratories operating high-pressure air lines, or where there are a series of liquefiers, may well investigate its adaptability. Its body is of brass and the



A diagrammatic vertical section of the Hampson liquefier showing essential characteristics.

A, expansion valve; B, valve stem; C, stuffing box; E, silvered glass Dewar cylinder; F, float valve; G, lifter for float valve; H, float; and a, a' regenerator coil.

needle of steel. Phosphor-bronze is recommended as a substitute for steel where moisture is present. High-pressure lines are joined to the valve by suitable unions. A thin gasket of pressboard is inserted between the flat faces and made air-tight by a nut. The copper line is welded with silver solder.

The liquefiers, constructed at the Bureau of Standards, have been described by J. W. Cook, assistant physicist. The regenerator coil is a copper tube, wound, starting at the top of the liquefier, in a spiral from outside to center for the initial layer. The winding then proceeds from the center to the outside for the succeeding layer, and continues on down the liquefier without a multiplicity of tubes and without retracing in the opposite direction from bottom to top. Incoming air, according to this arrangement, is forced to pass through the whole length of the regenerator. The spiral is wound on brass forms, and then the core is slipped out of one of the forms to permit removing the two halves of this form from the coil. The form is subsequently reinstated on the core from the other end and the winding is renewed. The performance is repeated until the whole length or 25 feet has been wound. The group of coils is pressed down into a series of nearly flat spirals; and the sections necessary for the regenerator are welded with silver solder. The finished regenerator coil is mounted permanently on a German-silver tube barely strong enough to act as a core and to support the apparatus.

A method has been devised to prevent the copper tubing, when being wound, from collapsing or flattening. The tube is filled with water by use of a hydraulic pump which maintains a constant pressure on the tube equal to the force at which the liquefier will be functioning with air. This pressure approximates 3,000 pounds to the square inch. If this method fails, the alternative involves filling the tube with water, freezing it in a bath of brine and ice, and then winding it while the water in the tube is congealed. Annealed copper tubing will not yield to the pressure of water once frozen within it, and if the winding is effected before the ice melts a true coil of small diameter is assured. The expansion valve is soldered at the lower end of the core and the regenerator coil is similarly silver soldered. A brass body valve and a phosphor-bronze or gun-metal needle may be coupled harmoniously. The expansion valve is operated from the top by manipulating a valve stem. This is a German-silver tube extending up the core and through a stuffing box, the latter putting a lever on the pressure only.

A sheet-metal cylinder of German silver is snugly fitted around the regenerator. Freedom of opening at the top is a guarantee that the gaseous air will be exhausted. An aperature at

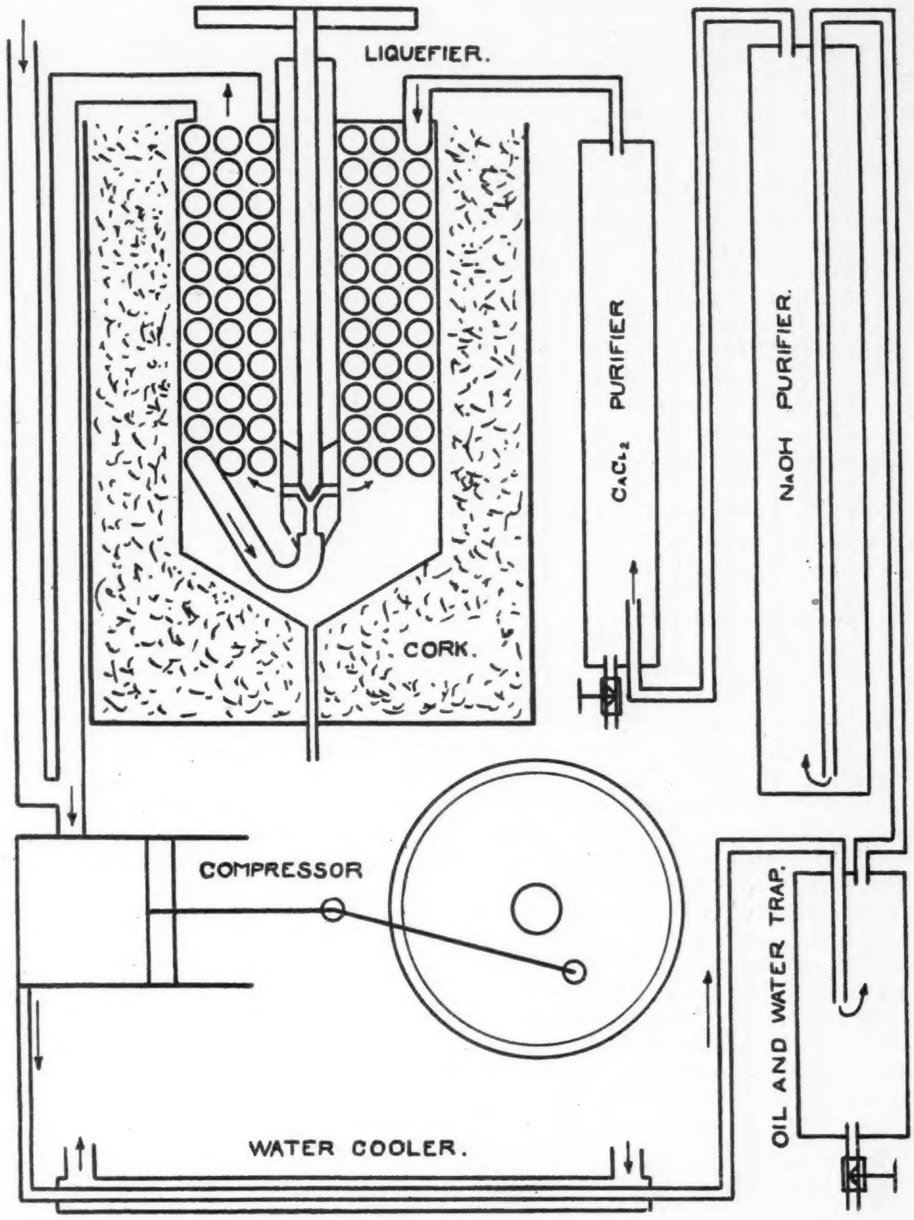
the bottom permits the liquid air to flow out. The entire liquefier is mounted in a Dewar vessel, provided with an outlet at the bottom. Three or four inches of "fine regranulated cork" is a satisfactory substitute for a Dewar vessel. This material is a commercial product resulting from grinding corkboard trimmings. An efficient liquefier discharges air in the liquid state from the bottom of the sheet-metal cylinder, already referred to, and the cold vapor is forced up over the regenerator coil and thence out at the top. A fixed, an adjustable, or an automatic outlet valve at the bottom will insure this desirable condition.

An adjustable opening involves constant supervision. A fixed aperture is uneconomical, as some cold vapor escapes with the liquid. The loss is direct. The third method, an automatic float valve, is highly efficient, provided it is properly designed. Observations at the Bureau of Standards show that violence of the air in the neighborhood of the expansion valve and in the vicinity of the float may lift the latter against gravity, hold the valve in abeyance, and forestall its operation. The installation of baffles to screen the float overcomes this inherent weakness. Without subscribing to any arrangement of baffles as altogether satisfactory, the Bureau of Standards has found several layers of fine copper gauze around the expansion valve of practical service. Moisture collecting around the float valve when the liquefier is idle has to be removed, for otherwise it would freeze when the machinery is set in motion. A mechanical device may be employed for lifting and holding open the float valve while dry air is circulated through the liquefier in advance of operation. Thus the moisture is disposed of and the float mechanism is not hampered in its disposition to open and close automatically. Ferrous metal is tabooed from this portion of the liquefier as rusting would invite trouble.

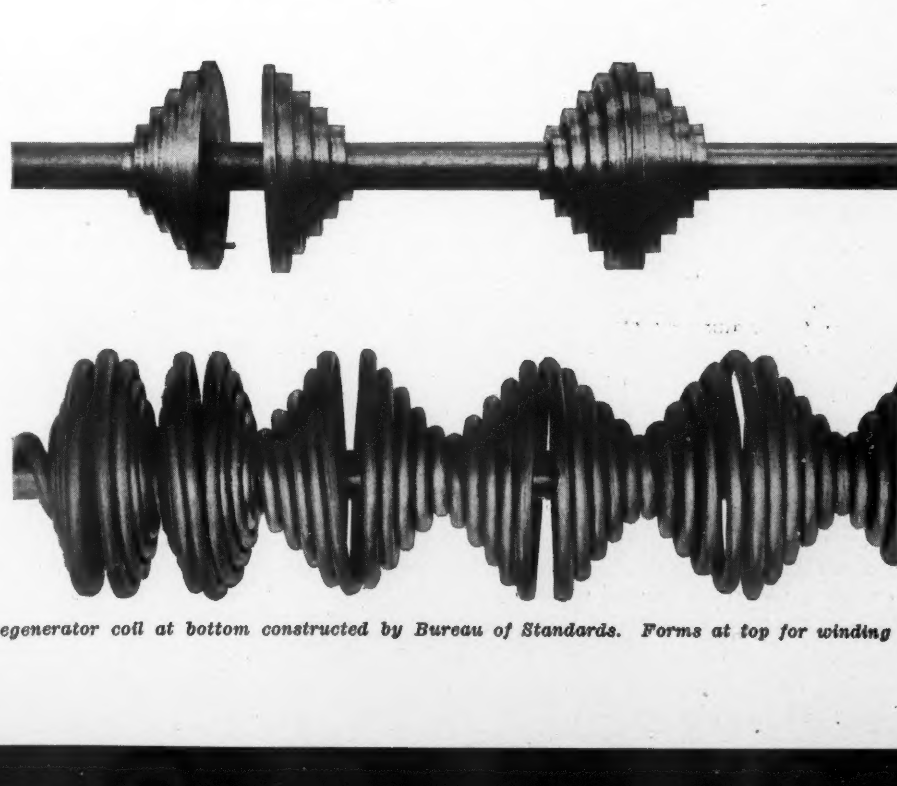
Once the liquid-air outfit is in operation, the air after compression is cooled with running water to approximately 20°C. Further cooling of the air is advisable before it reaches the liquefier, which may be accomplished by submerging a line of copper tubing in a tank supplied with ice and salt. In a refrigerating establishment, where a still lower temperature is available—one using ammonia or carbon dioxide—a precooler should be incorporated in the liquefier above the regenerator coil.

Water vapor and carbon dioxide are disposed of in the interest of pure air. The former, for the most part, is condensed during the squeezing process, and a trap is located to corner this water. It can be extracted at intervals, together with the oil employed for lubricating the compressor. The air is subsequently conveyed through a container, as previously described, where it bubbles through a solution of sodium hydroxide, the latter eliminating the carbon dioxide. Thence passage is made over calcium chloride, which discards the water vapor.

The efficacy of this method is not to be gainsaid when the Hampson process of liquefaction is employed. The purifier is the primary element of danger in the production of liquid air, as it contains a substantial volume of air



Mechanical arrangement of liquid air system.



Regenerator coil at bottom constructed by Bureau of Standards. Forms at top for winding coil.

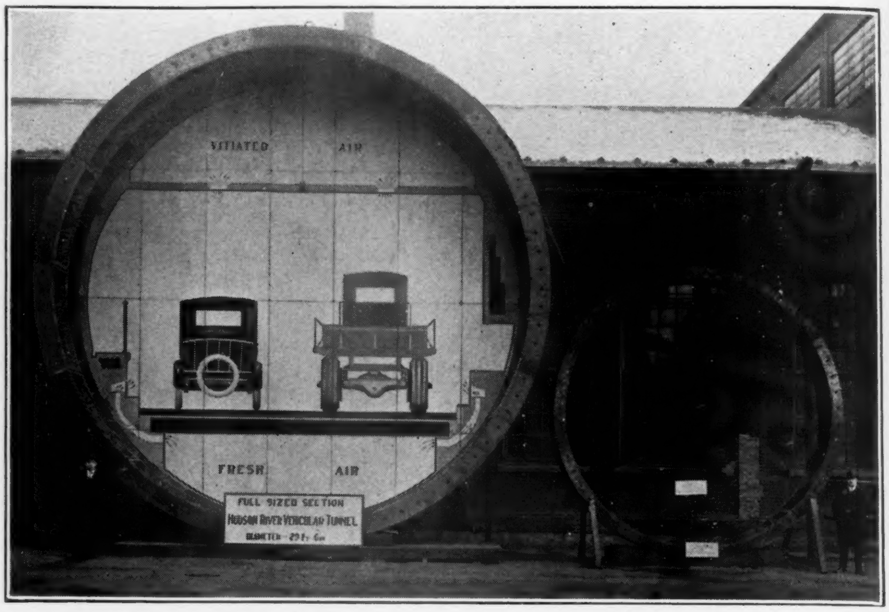
under high pressure. This mechanism therefore, should be designed with regard to safety, and tested under hydraulic pressure in excess of the force under which it functions when manufacturing liquid air. Each stage of the compressor is provided with a spring safety valve, the one on the last stage acting as the protecting unit for the liquefiers, purifiers, and the compressor. A suggestion is offered by the Bureau of Standards that a check valve, similar to the outlet valve of the last stage of the compressor, be stationed in the air line between the first purifier and the high-pressure safety valve on the compressor to forestall a possible back flow of air in the event of mishap to this safety valve or to the compressor outlet valve and the gasket under the high-pressure cylinder head.

J. W. Cook, specialist in the production of liquid air at the Bureau of Standards, makes the following fundamental pronouncement on the subject:

"It is well to call attention to the fact that the total cold available is determined by the initial temperature and pressure of the air at the point where it enters the regenerator and the exhaust pressure, which in practice is one atmosphere. It is independent of the internal construction or arrangement of the liquefier, of the material used in its construction, of the distribution of temperature in the regenerator coil, and of all other circumstances whatever, provided that the kinetic energies of the feed and the exhaust are negligible. This cold is used in the following three ways: (a) To offset the heat that leaks into the liquefier from outside, either through the insulation or along the metallic component parts of the liquefier; (b) to cool the whole quantity of gas from its initial temperature to the slightly lower exhaust temperature; (c) to cool a fraction of the air from this exhaust temperature to the normal boiling point and then condense it into liquid.

"From these facts it is evident that to obtain the maximum amount of liquid air with a given expenditure of power a Hampson liquefier must be so constructed that the factors (a) and (b) are kept as small as possible. This results in a compromise, however, for by increasing the size of the regenerator indefinitely, which would make (b) negligible by exhausting at practically the initial temperature, the size of the liquefier, over all, is necessarily increased, thereby increasing (a), the heat leak. It is, therefore, apparent that, to be efficient, a liquefier should be as small, over all, as will exhaust air at a temperature just slightly below the initial temperature, which may be about room temperature or may be considerably lower if a precooler is used. The size of the regenerator coil required would be determined chiefly by the capacity of the compressor furnishing the air and by the temperature of the air entering the regenerator. Obviously, if a precooler is used, the size of the regenerator may be decreased.

"In the foregoing discussion it has been assumed that the liquefier has been in operation long enough for complete thermal equilibrium to have been reached. Under these conditions the actual heat capacity would not be a factor. If a liquefier is to be run only intermittently for the production of small amounts of liquid at a time, the heat capacity of the liquefier will be an appreciable factor, influencing the length of time required to cool down the liquefier when starting, and effectiveness of heat interchange can be advantageously sacrificed in order to reduce the heat capacity."



See and believe is the best way to realize just what the vehicular tunnels represent in the way of magnitude. Each of these tubes will be made up of an aggregation of metal rings composed of fifteen separate segments so bolted together that the tunnels will be water-tight and rigid when finally in place. Throughout the greater part of their lengths, the rings of the twin tubes will have an outside diameter of 29 feet six inches, but on the New Jersey side of the river, in order to meet certain ventilation requirements, one of the tubes will have its external diameter increased to 30 feet four inches. The smaller tunnel section at the right is a full-sized ring such as was used in the construction of the Hudson and Manhattan tubes, and the outside diameter is sixteen feet two inches. It is interesting to note that the maximum diameter of the new subaqueous highway will be four inches greater than that of the famous Rotherhithe Tunnel under the River Thames, London, England—heretofore, the largest under-water tunnel in the world. All told, the twin tubes of the Hudson River Vehicular Tunnel will be composed of 5,400 rings, and the number of unit castings required will total substantially 81,000. The Bethlehem Steel Company is making the ring castings for the present undertaking as it did in the case of the Hudson and Manhattan tubes twenty-odd years ago.

GUNITE IN COAL MINES

AT A RECENT meeting of the Junior Section of the North of England Institute of Mining and Metallurgy, Mr. William Ridley described the advantages of gunite for use in coal mines. The early attempts to lay cement by compressed air were not very successful, on account of clogging, but the advent of the cement gun completely changed this owing to the different principle involved. In the case of the cement gun the material is forced out dry—hydration of the mixture being effected just prior to its projection, so that clogging cannot occur. The consistency of the gunite is easily regulated by the nozzleman.

Tests have shown that gunite applied by compressed air excels handwork by 20 to 260 per cent. in tensile strength; by 20 to 270 per cent. in compressive strength; by 43 to 1,900 per cent. in surface impermeability; by 40 to 430 per cent. in resistance to water absorption; by 33 to 92 per cent. in volume of voids; by 27 per cent. in adhesion; and by 12 per cent. in weight.

Gunite is used in the construction of buildings; in the protection of headgears and other steelwork from the action of the elements; for fireproofing timber, drifts, underground roadways and stables; and for forming brattices in headings. Roofs which scale owing to weathering may be cured by gunite; and it is an efficient medium for sealing dams, air crossings and air stoppings, and for repairing cracks and fissures in existing arches of brick or concrete. It is not intended for the support of roadways in place of heavy timbering. In the subsequent discussion of Mr. Ridley's paper, members spoke very favorably of their experiences in the practical use of gunite in mines.

R. H. B.

DENMARK TO MANUFACTURE ITS OWN NITROGEN

DURING the World War the Danish authorities came to realize the menace to their agricultural industry in dependence upon imported fertilizers. As a result, the government, in 1918, granted 20,000 crowns annually for three years to be used for investigating the possibility of manufacturing nitrogen in Denmark.

The commissioner appointed by the Rigsdag has recently made his report, and this, in brief, states that Denmark could produce its own nitrogen and at competitive figures. The cost of producing one kilo of nitrogen in countries having their own coal supply, and with coal at ten crowns per ton, has been calculated at 91.5 öre (an öre is worth about a quarter of a cent), whereas in Denmark, with coal at twenty crowns per ton, it would cost 100 öre. Prior to 1914 something like 50,000 tons of Chile saltpeter, corresponding to 8,240 tons of nitrogen, were consumed annually in Denmark.

Pneumatic Tools Hasten Building of Electric Transmission Line

By F. A. DENCER and A. S. TAYLOR

A BIG public service corporation in the Keystone State has been called upon to erect in the shortest practicable time a large number of steel towers for a new transmission line.

This work has necessitated pushing the job ahead during a rigorous winter over an exposed stretch of country, and it has further entailed dependence upon a single operating base.

The executives responsible for the prosecution of the task have attacked their problem in a decidedly novel manner by calling to their aid an unusual array of pneumatic equipment.

With these facilities, it has been found possible to advance the work at a rapid pace in the face of conditions which would have proved staggering had ordinary hand methods been employed.

AMERICA'S consumption of electrical energy far exceeds that of any other nation. Year by year we become more and more dependent upon electricity for purposes of lighting, heating, and motive power.

During 1922, our electric light and power industry sold fully 50,000,000,000 kilowatt-hours of energy; and the gross revenue realized from that service amounted to nearly $1,100,000,000. This represents an increase of quite 12 per cent. over the intake for the preceding twelvemonth. The point that should be kept in mind is that the demand for a greater volume of current is growing annually at a rate which is soon going to tax existing power plants to their utmost.

The problem confronting our electric public service companies is a decidedly complex one, and a solution must be found because ways will have to be discovered which will enable these enterprises to keep pace with the needs of their present and their potential customers. It is apparent to everyone familiar with the subject that relief cannot be obtained merely by expanding existing isolated plants or independent systems. To do this in a reasonable period of time would call for the expenditure of large sums which are not now to be had for the asking. In other words, the generating equipment available must be utilized to greater advantage—in short, be operated more effectually, more efficiently, and more economically than is generally the case.

Experts are aware that this goal is attainable whenever the diversity factor is such that the loads respectively for light and power can be distributed over the whole day so that the flood tide of service will be at a fairly constant level and not subjected to radical fluctuations. Further, the engineers realize that this end can be achieved to a notable extent by recourse to the interconnecting of separate systems in which the peak loads do not occur at the same time. By this arrangement, the reserve machinery or the surplus output of one plant can be turned into a common trunk line of transmission wires and dispatched hither and thither to supplement the current supplied by central stations that otherwise would be overtaxed.

This, in principle, is the idea underlying the proposed Boston-Washington superpower zone, and, on a lesser scale, is exactly what has been done and is being done by the more enterprising of the great concerns which are now engaged in generating and distributing large blocks of electrical energy over widespread territories in different parts of the United States. There is every likelihood that the interconnecting of electric transmitting and distributing systems will be actively pushed henceforth and for a number of years to come; and this work will engage the close attention of construction and maintenance engineers upon whom will rest the burden of erecting the towers and of stringing the lines at the lowest cost in keeping with permanence and acceptable workmanship.

These results can be realized through the employment of certain up-to-date agencies which make it practicable for a laborer to do his work faster and better than is commonly the case, even when contending with rather severe conditions. By way of example, let us tell the story of how a public service utility in Pennsylvania has blazed the way in this field and is setting a heartening example that

"Jackhamer" drilling holes in tough limestone preparatory to blasting an excavation for a foot of one of the steel transmission towers.

Tamping the backfill about the foot of a transmission tower so that the earth will be tight enough to prevent any subsidence or shifting of the steelwork.

others may follow to their gain. The Metropolitan Edison Company of Reading, Pa., and the Pennsylvania Edison Company of Easton, in the same state, are engaged in linking their transmission lines so as to provide a transmitting and distributing system which will enable a number of their plants to operate more economically in combination than it is practicable for them to do when running as independent units. The intention is also to join in a similar manner the generating plant at Reading with the electric power station at Harrisburg.

The total distance, by air line, between Easton and Harrisburg is approximately 75 miles; but inasmuch as the right of way for the transmission system must follow a more or less zig-zag route along valleys and from hill to hill, the actual length of the two sections will necessarily be somewhat longer than the distance mentioned. According to the estimates of the engineers, there will be erected about 500 towers between Easton and Reading, and about the same number between Reading and Harrisburg. The steel transmission towers vary in height from 66 to 80 feet, and they will be set up at an average distance of 800 feet apart. Where the wires can be strung from towers on adjacent hilltops, the towers may be separated by as much as 3,000 feet. Depending upon the gap between these structures, and the load to be carried by them in each case, the towers will range in weight from 7,200 to 14,000 pounds. They will be formed of fabricated steel which will be assembled on the spot in the field. The transmission wires will be six in number and each will be made up of a single 3/16-inch steel core embedded in an aluminum envelope.

The country traversed by the Pennsylvania Edison Company's link of the new system is hilly, largely rugged, and much exposed; and every effort has been made to carry on the work with all possible dispatch throughout the past severe winter. Before describing how success in this effort has been attained, it might be well to mention the excavating required in placing the underground footings of the transmission towers. In order to provide satisfactory foundations for the towers, the lower end of each of the legs is secured to an anchor consisting of a rectilinear grid constructed of angle bars, I-beams, and channels. These anchors, four in number for each tower, with their attached lower leg sections, are set at the bottom of a like number of rectangular holes averaging about six feet square and nine feet deep. The grid work or anchor is five feet square. Depending upon the size of the towers, the anchors are located at the corners of squares measuring from seventeen feet to 22 feet on a side.

The sites for the associate footings are carefully determined by the surveyors, and with this done the digging starts. Owing to the nature of the country and to weather conditions during the winter months, the working gangs have had to contend with many difficulties, and these were considerably aggravated the farther the men got away from their supply and operating base at Easton. Ordinary hand methods of excavating, backfilling, and otherwise dealing with different aspects of the task would have proved ineffectual and very expensive, and progress would have been decidedly slow. The job often called for digging into ground frozen to a depth of two feet; in clearing away much hard rock; in breaking up excavated soil that had become frozen; and in backfilling and tamping the earth around the anchors and about the lower leg sections so as to hold them firmly against subsequent settlement or other movement.

These things have all been done, to the complete satisfaction of the men in charge, by reason of the employment of such pneumatic tools as "Jackhamers," paving breakers, clay diggers, and sand rammers, which have obtained the needful operating air from portable gasoline-engine-driven compressors. At the beginning of the undertaking, the air was furnished by a 6x6-inch compressor mounted on a perfectly balanced, 2-wheel, rubber-tired, special trailer. This trailer was designed by Mr. E. L. Tirrell, one of the engineers of the Pennsylvania Edison Company. Because of the rather unique mounting, it was possible for a 5-ton caterpillar tractor to haul the trailer to the working positions even when the roads were in their worst condition. Indeed, the tractor was able time and again to draw the portable compressor up the roadless slopes of steep hills to the rather inaccessible sites selected at some points for the erection of towers. Again, the same trailer is hooked to a powerful motor truck.

As might be expected, the tendency on occasions was to overload the compressor, which has a piston displacement of 118 cubic feet per minute. That is to say, as many as seven pneumatic tools of various kinds were using air simultaneously. This naturally caused the available air pressure to drop to about 50 or 60 pounds, which, of course, is too low for the efficient operation of the tools. With five tools on the line, however, the 6x6-inch compressor was able to maintain an ample supply of air at a pressure of 100 pounds. The field equipment is to be increased by an 8x8-inch portable compressor, similarly mounted on a 2-wheel, balanced trailer. This machine is of a type which can furnish 210 cubic feet of air per minute at a pressure of 100 pounds.

Now let us consider the various ways the pneumatic tools were utilized and are being employed in securing the anchors and the lower leg sections of the transmission towers. In starting an excavation, paving breakers were relied upon to get through the top soil whenever the ground was frozen or too hard for the clay diggers to penetrate it effectively. The paving breakers have also proved useful in shattering large pieces of rock so that the rock could be disposed of by hand shovels. The sand rammers have been employed to deal with material that was too resistant for hand tamping; and these rammers have been found extremely serviceable and satisfactory in packing the backfilling into place around the anchors and the underground parts of the tower legs. By recourse to this procedure it has been possible to avoid the employment of cement or any sort of hydraulic filling; and there is ample reason to believe that this has been the means of saving a good deal of time and expense. As a matter of fact, an abundance of water has been encountered only infrequently at the tower sites, and dry backfilling has, therefore, been especially advantageous.

The tower footings have been uniformly set in place some while in advance of the arrival of the steelwork for the above-ground sections of the towers. This has required that the positions of the footings should be established to a nicety so that the subsequently attached structural angle bars, etc., should come together properly and insure the correct alignment and uprightness of the finished towers. To this end, a rectangular template, braced diagonally, is used in placing the anchors and in adjusting the vertical slant of the four bottom leg sections. The latter sections, for the time being, are bolted to the template. While held in this manner, the backfilling is done and the earth thoroughly tamped.

Experience has revealed that the clay diggers are capable of penetrating sticky mud or any firm earth that is not filled with stones. These tools have also performed well in breaking up excavated, frozen earth so that the dirt could be disposed of readily by hand shoveling. The clay diggers have likewise been effective in carrying the excavational work right down to the bottom of the anchorage pits; and at all times the tools have shown themselves decidedly economical in their consumption of air. With some of the men using diggers and others operating rammers, it has been possible to go ahead at good speed on all phases of this foundation work; and fine progress was made even when the winter weather was most severe.

In places where limestone has been encountered in excavating the anchorage pits, "Jackhamers" have been utilized to drill the needful holes for blasting. The steels used have been ⅞-inch, hollow hexagon, with 4-point bits. At times, as many as twenty holes, ranging from two to three feet in depth, have been drilled at each tower site. The blasting has been done with 40 per cent. dynamite—one pound of the explosive being tightly tamped in each drill hole.

For some months all of the drill steels employed on the job were sharpened by a No. 33 "Leyner" sharpener set up in the blacksmith shop, at Easton, of the Pennsylvania Edison Company. This necessitated the transportation of the fit and the unfit steels to and from Easton as the foundation workers got farther and farther from that base. It is now proposed to mount the jacksteel sharpener on one of the electric company's motor trucks so that this indispensable machine can be kept close to the work in the field, reducing thereby the transportational charges.

It is worth while to emphasize the fact that pneumatic tools and portable compressors have enabled the Pennsylvania Edison Company, so it is authoritatively stated, to perform the work so far finished at half the cost of similar jobs previously executed by the ordinary hand methods or facilities. Before this whole undertaking is completed a still wider use of compressed air may be resorted to, and we shall tell this story in due season. In the meantime, enough has been said about the advantages to be realized by the employment of pneumatic tools to be of suggestive value to others who may be engaged in putting through similar or kindred constructional undertakings.

The Compressed Air Equipment in Action in the Field

Fig. 1—Pneumatic clay diggers have proved themselves exceedingly useful in breaking up piles of frozen, excavated earth so that the material could be disposed of afterwards by hand shovelers. This has meant the saving of much time and money.

Fig. 2—The anchors of the four legs of a transmission tower held in place in the pits by a steel-framework template.

Fig. 3—A caterpillar tractor has been found useful in pulling up to rather inaccessible sites the trailer carrying the compressed air plant.

Fig. 4—A Type Fourteen portable compressor mounted upon a special 2-wheel, rubber-tired trailer. This arrangement, like all trailer mountings, has made it possible to draw the power plant for the pneumatic tools over the roads when in their worst condition.

Fig. 5—A pneumatic clay digger breaking up frozen backfilling.

Compressed Air in the Portland Cement Industry

By G. S. EATON

COMPRESSED air has two principal fields of usefulness at a Portland cement plant—furnishing power for the drills in the rock quarries that supply the raw materials, and for operating various pneumatic tools in the machine shops, for work around the grinding equipment, for doing odd jobs, and for cleaning up. At some plants, it is also used for blowing the powdered coal, or other fuel burned, into the huge revolving kilns where the raw materials are transformed into cement-clinker. For these and other purposes, practically every cement plant maintains some sort of compressed air equipment which, naturally, is called upon to do service in proportion to the rate of production of cement.

Starting a "gopher hole" or tunnel in the face of a limestone quarry. On blasting with black powder 25,000 tons of rock is sometimes broken loose.

That rate has been unusually high since the activity in construction became so marked something over a year ago. The wide use of concrete in pavements and all sorts of structures resulted in such a demand that 113,870,000 barrels of cement were produced in 1922, according to the United States Geological Survey.

Output and shipments since the first of this year have continued at a high rate, as the plan of keeping up building activity throughout the winter months gained greatly in favor among architects, engineers, and contractors, with the result that the demand for cement is becoming less seasonal. Although the 1922 cement production was bigger than ever before, the plants, according to commonly accepted estimates, were operating for the year at less than 80 per cent. of their capacity, which leaves a large margin in reserve, if needed, for 1923. Compressed air, as usual, will play an important part in helping to meet the country's requirements, for first of all the raw materials must be taken from the earth before they can be manufactured into cement.

To supply the great quantities of limestone and shale needed annually by the country's cement mills, many enormous quarries are operated. While a number of different materials may be successfully utilized in cement manufacture, by far the most important constituent in point of quantity is limestone. This may be used with clay, shale, or blast furnace slag, in proper proportions, to provide the necessary amounts of lime, silica, and alumina. In some instances, marl furnishes the lime, and in that case dredging takes the place of quarrying. The so-called cement rock is a limestone containing the clayey ingredients (silica and alumina) in about the correct proportions for cement manufacture. Quarrying the limestone and the shale—the latter in lesser degree—requires endless drilling and blasting.

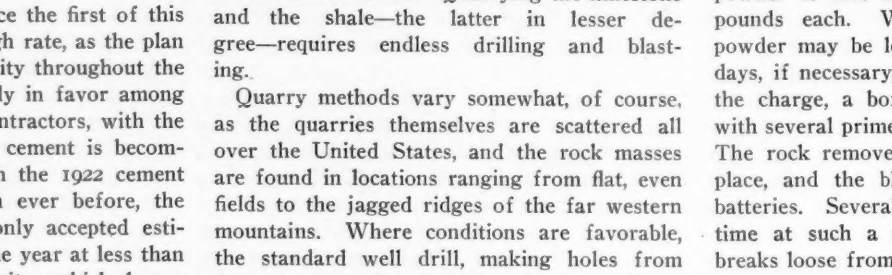
Quarry methods vary somewhat, of course, as the quarries themselves are scattered all over the United States, and the rock masses are found in locations ranging from flat, even fields to the jagged ridges of the far western mountains. Where conditions are favorable, the standard well drill, making holes from four to six inches in diameter, is employed for the primary shots, and "Jackhamers" are commonly used for the "pop-shooting" that is needed to break up the larger pieces into fragments the steam shovels can handle. Single-face operation is of course preferred. Pneumatic equipment is practically always used in the secondary blasting.

In cases where the quarry is located in a mountainous region some other method of drilling must usually be employed. The blasting of small tunnels—called "coyote holes" or "gopher holes," that are later filled with black powder or other explosives, is a plan successfully followed. In one instance, a tunnel three to four feet in diameter is blasted into the rock perpendicular to the quarry face for perhaps 40 feet. Then it is divided to form the head of a tee, with the cross-cuts, or branches, parallel to the quarry face. Drilling is done with compressed air "Jackhamers." These branches are then filled with black powder, which is hauled in over a wooden track laid through the tunnel.

In a dry hole the powder is tamped in place, but if it is wet the seams in the metal containers are coated with heavy grease and the powder is left in the cans, which hold 25 pounds each. With this precaution, black powder may be left in wet holes for several days, if necessary, without injury. To set off the charge, a box of 40 per cent. dynamite with several primers is placed with the powder. The rock removed is then tamped back into place, and the blast is set off with electric batteries. Several coyote holes are shot at a time at such a quarry. The average blast breaks loose from 25,000 to 30,000 tons.

In another western plant, where similar methods are employed, the limestone quarry face rises as much as 500 feet above the floor. In this case, shale is secured from an extension of this same quarry, at which point it is about 250 feet in height. Forty per cent. ammonia dynamite is the explosive used. Here the practice is to use enough explosive in a single blast to break off from 80,000 to 100,000 tons of lime rock, working with a face 150 to 200 feet high.

In a few instances, where the desired strata of rocks are covered too deeply by overburden for economical stripping and where there is an adequate roof of other rock, materials for cement making are mined. Small power shovels, operated by compressed air, are advantageously employed in one or two

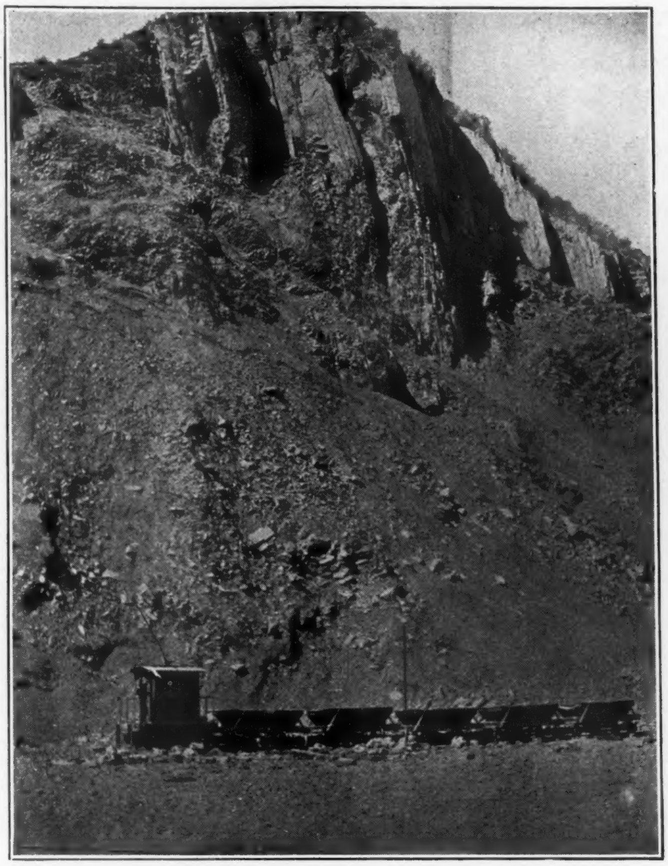


A Portland cement mill quarry. The huge steam shovels which handle the broken rock look scarcely larger than toys under the shadow of the face of the quarry.

such cases for loading the blasted rock upon cars, just as huge steam shovels do in open quarries.

Three barrels of cement is a common yield, exclusive of fuel, from a ton of raw materials quarried or excavated. About 620 pounds of raw materials must be actually started through the mill for every barrel of cement that is to emerge, and as a barrel of cement weighs only 376 pounds, it is evident that the loss in manufacture is large. Moisture accounts for some of this loss, but by far the greatest part of it lies in the enormous quantities of carbon dioxide driven off from the limestone as the raw mix is heated in the kilns. All this carbon dioxide is dissipated long before the materials reach the clinkering stage, inasmuch as that point is reached only at a temperature of from 2,500 to 3,000° F.

In producing such an extreme heat, compressed air often plays a part, as it is generally employed to atomize oil in the plants where petroleum is burned and sometimes to feed coal into the kilns. Pulverized coal is the fuel ordinarily used, but, where available at a reasonable figure, oil or natural gas answers the purpose excellently. The fuel must burn instantly and almost completely in order to produce the extreme degree of heat necessary for the proper chemical transformation of the finely ground raw materials into cement-clinker. Good practice now insists that coal shall be powdered so fine that from 80 to 85 per cent. will pass through a sieve having 200 meshes to the linear inch, or 40,000 holes to the square inch. About 200 pounds of coal to the barrel of cement weighing 376 pounds is an average requirement.



The towering 500-foot face of a limestone quarry. An electric locomotive draws off to the crushers trainloads of rock.

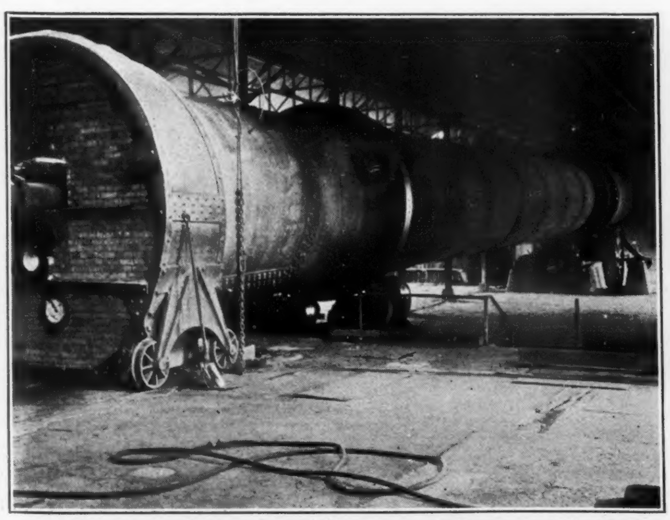
Although screw conveyers are commonly employed in transporting the pulverized coal from the grinding mills to the feed bins above the kilns, compressed air is now successfully utilized for this purpose at some plants by recourse to especially designed equipment. When high-pressure air is used in the kiln feed, the coal is conveyed out of the bin and allowed to drop into an injector, where it mingles with the air that is passing through. The current of air and coal dust is then blown into the kiln by the injector that terminates in a nozzle of wrought-iron pipe, which pierces the hood and projects a foot or more into the kiln. High-pressure air is usually supplied at from 60 to 80 pounds. Only 10 per cent. of the total air needed for combustion is provided at this pressure, as the principal object is to carry the charge of coal well into the kiln.

Sometimes air at low pressure and from a fan is used instead, in which event approximately 20 per cent. of the total volume necessary is blown in with the coal. Occasionally, a combination of high and low-pressure air is employed. The remainder of the air required for combustion enters by way of openings around the hood and through the clinker discharge area at the end of the kiln.

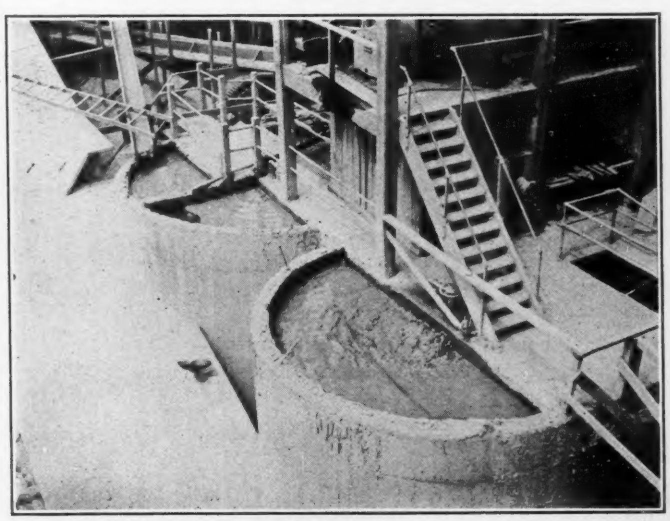
In a kiln of present-day design—say 150 to 200 feet in length and eight to ten feet in diameter—the flame will extend at least 25 to 30 feet into the interior. Raw materials enter at the upper end of this great cylinder, which has an inclination of from ½ to ¾ inch to the foot, and gradually move down as the kiln slowly rotates. After passing through the clinkering zone, they drop from the kiln in the form of white-hot balls ranging from ¼ inch to two inches in diameter. Later this clinker is ground into the extremely fine powder known as Portland cement, a substance so fine that at least 78 per cent. of it can pass through a sieve having 40,000 holes to the inch—a sieve that will hold water. A small percentage of gypsum, ground up with the clinker to retard the setting time of the cement, is the only material added after the burning.

Still another use for compressed air is sometimes found in preparing materials for the kilns. Two general processes of manufacture, called the "dry" and the "wet," are followed. In the former process, materials are thoroughly dried out before they are ground, whereas in the latter water is necessarily added to make the mixture sufficiently fluid for pumping. The wet process is resorted to where marl is one of the ingredients, but it may also be used with quarried materials.

The wet mixture is called slurry. This commonly contains about a third of water by weight. In order to prevent the particles from settling while the slurry is in the tanks, pro-



One of the great rotary kilns in a Portland cement plant. Here the raw materials are subjected to a temperature of more than 2,500°F.



Slurry tanks in a Portland cement plant using the wet process. Here compressed air is employed to agitate the mixture.

vision is made for blowing compressed air up through the tanks to agitate the mixture continually. The boiling up of the air bubbles at the surface of the slurry is a familiar sight in wet process plants.

Because of the rapid wear on the machinery employed in making cement, the result of the nature of the materials crushed and ground, repairs must be made frequently. A well-equipped machine shop is an essential adjunct to a cement plant, and various pneumatic tools, such as chisels, hammers, riveters, hoists, jacks, and reamers, are usually a part of the shop equipment. An air blast is also most useful in cleaning up around the shop machinery and in the grinding buildings. The practice is to maintain a large stock of repair parts in reserve at the plant so that any failure in equipment may be speedily made good.

Through control methods, which have been worked out during 50 years of cement manufacture in the United States, the producers in all parts of the country, using widely differing materials, are able to furnish a product that will meet the rigid requirements established by the American Society for Testing Materials and by the Federal Government. The first tests are made while the materials are still in the ground, for the borings from the drills are taken to the chemical laboratory for analysis. Throughout the long manufacturing process, both chemical and physical testers are vigilant to maintain uniformity.

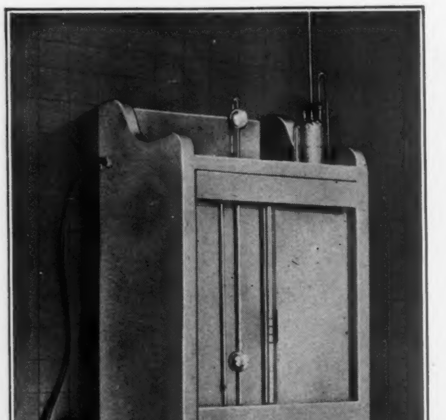
When the finished cement is shipped out for use on construction work, it immediately occasions a demand for several times as much of other materials to serve as aggregates in making concrete. Crushed trap, granite, and limestone comprise a very large share of these aggregates; and, accordingly, there is need for blasting agents and compressed air equipment in the actual use of cement as well as in its manufacture.

COMPRESSED AIR FOR LIQUID CHLORINE APPARATUS

A NEW liquid-chlorine apparatus for the manufacture of chlorine, hypochlorite of soda solution, and other chlorine compounds, has recently been perfected for use in textile and bleaching establishments, laundries, hospitals, hotels, etc. The apparatus consists of a porcelain tank enclosed in a light-proof cabinet. At the base of the tank there is a chlorinating device through which the chlorine passes and is rapidly diffused and absorbed by the contents within the tank. As the fluid is withdrawn, the tank is replenished from E through pipe G.

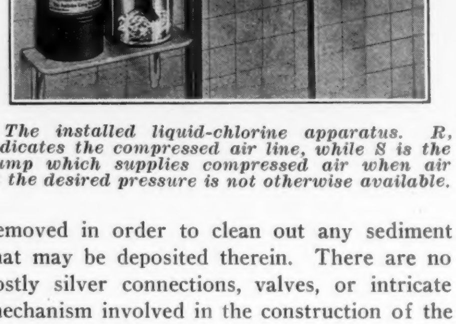
In an accompanying illustration, H represents a graduated tube, whose base connects with the interior of B, that indicates the amount of liquid in the chamber. The graduations correspond to pints, quarts, and gallons, so as to enable the operator to measure off any desired quantity. For the purpose of thoroughly mixing the contents, compressed air from a hand pump or some other source is forced into the chlorinator.

The lower section of the porcelain tank is a glass bowl, by means of which the feed of the chlorine can be watched. This can be easily



The installed liquid-chlorine apparatus. R, indicates the compressed air line, while S is the pump which supplies compressed air when air at the desired pressure is not otherwise available.

removed in order to clean out any sediment that may be deposited therein. There are no costly silver connections, valves, or intricate mechanism involved in the construction of the chlorinator: the entire device is made of



H, graduated tube that indicates the amount of liquid within the chlorinating chamber, B. G, is the pipe by which the tank B is refilled to make up for the liquid drawn off at E.

porcelain and glass. The apparatus can be used in a closed room inasmuch as it does not give off the slightest odor of chlorine. This is due to the ingenious method by which the container is constructed.

One of the photographs shows the equipment as adapted for sterilizing water supply systems, swimming pools, etc. This is what is known as a single-unit chlorinator. For use in a large laundry, for example, three of these units are so interlinked that water, caustic solution, and soda solutions may be chlorinated at one and the same time, while permitting them to be withdrawn separately as they are needed. This flexibility of control enables the operator to mix, at a moment's notice, any standard bleach, such as chlorinated water, chlorinated-soda solution, and combinations of caustic-soda solutions. This is of great advantage to a laundry or a dyeing establishment where small quantities of bleaching fluids of varying kinds and strength are required off and on throughout the working day.

The compressed chloride gas is shipped to the users in steel drums, and on entering the chlorinator is instantly absorbed by the different solutions. A laundry equipment includes three containers—one for water, another for soda solution, and a third for caustic solution, and these are usually placed on the floor below the apparatus. These solutions are so stored that they can be forced up into their respective compartments in the apparatus by compressed air. For some laundry work only chlorinated water is required, while other work calls for a certain amount of soda and caustic solution. For that reason, the facility with which different bleaching fluids can be combined as desired by the apparatus makes it especially adaptable. It is not necessary to place the three containers in the same room with the chlorine apparatus —they can be located in the basement, inasmuch as compressed air is capable of forcing the liquids to any needful height.

The advantage of this system for the purposes outlined over the use of chloride of lime, commonly known as bleach, is that chlorine gas is a chemically pure product, and, furthermore, does not lose its strength. This is of outstanding importance, especially for small installations. Under working conditions, due to the wastage of bleach, one pound of liquid chlorine is equal to from six to eight pounds of chloride of lime. The liquid-chlorine apparatus is far more compact than other installations, and requires little or no attention. The saving accomplished by the substitution of liquid chlorine for chloride of lime is said to be in excess of 50 per cent.

SUGAR DUST EXPLOSIONS

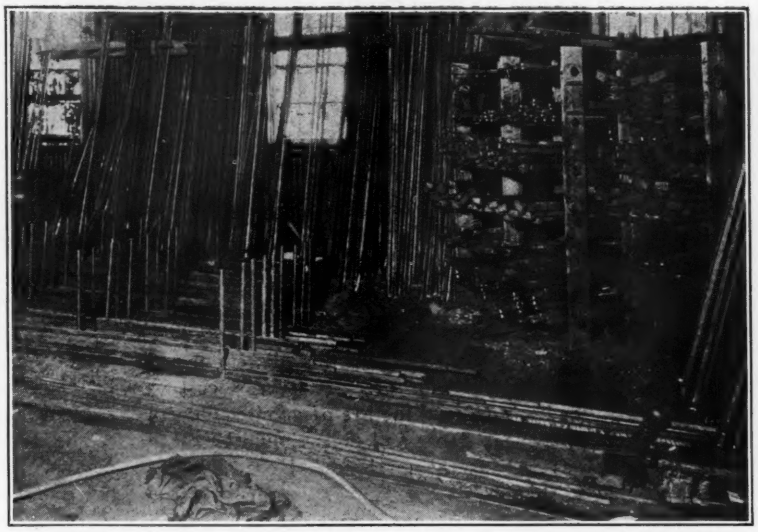
Sugar dust seems to be capable of forming a most dangerous explosive mixture. A translation in *Sugar* of a German article by Beyersdorfer tells of 67 sugar-dust explosions in German sugar plants. A factory in Frankenthal had an explosion in 1916 and another in 1917, causing the death of thirteen and wounding 38 in 1916 alone, besides destroying equipment and buildings. Plants in Frellstedt, Stuttgart, Uerdingen, etc., were burned down as the result of sugar explosions.

Drill Steel and the Drill Steel Sharpener

PART IV

By FRANK BLACKWELL

THE CONCLUDING installment of this series brings to a focus the fact that nothing must be taken for granted, nothing must be slighted if the miner and his tools are to give the best practicable account of themselves. The drill runner must be trained to take proper care of his equipment while it is in his hands; and it is equally essential that the employer see to it that the miner has good tools in the first place and that they are kept in first-class running order. To meet these several requirements certain essential things must be done, and these will now be broadly outlined.

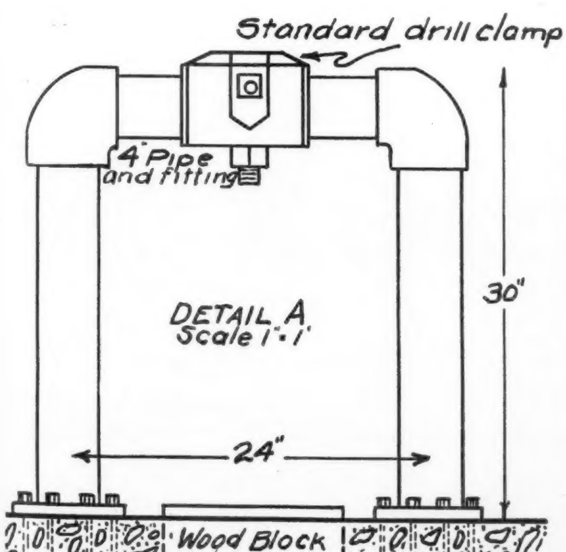


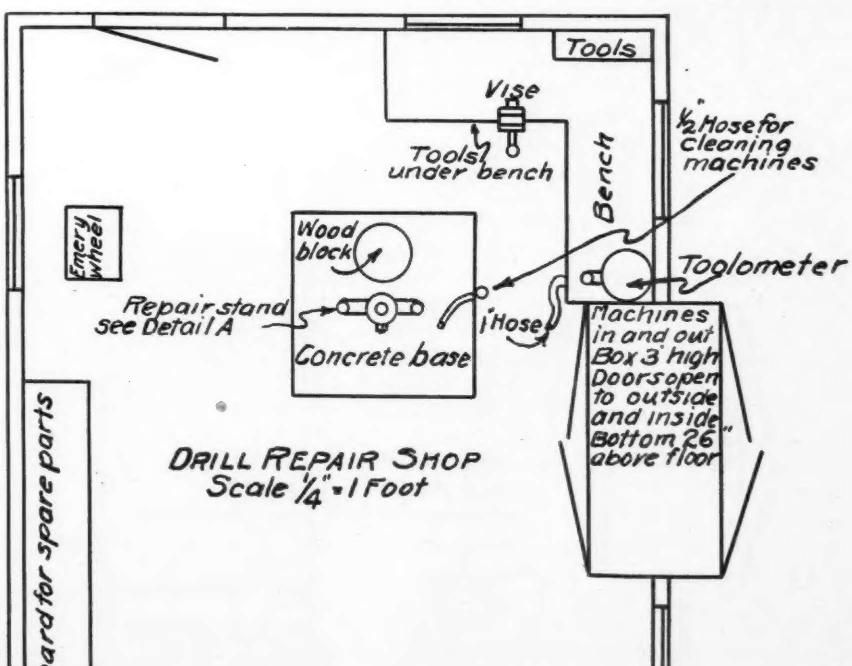
The drill-steel supply in the blacksmith shop of a large mining enterprise.

The proper lubrication of drilling equipment with the right grades of lubricants is one of the most important features of efficient rock-drill operation and maintenance. By following the methods outlined in the preceding chapters the efficient life of drilling equipment is greatly lengthened by reducing wear on all parts, and breakage is kept down to a minimum. When we consider the number of revolutions made by a rock drill hourly we are better able to realize why such a machine should be properly lubricated. Taking an average of 1,200 blows per minute, a rock drill will make 72,000 blows in one hour of actual reciprocating time. The lubricating of pumps, compressors, and engines traveling at 50 to 200 R. P. M. is not neglected, so why should not the proper lubrication of a high-speed machine like a rock drill be given due consideration?

The average miner does not realize the importance of lubrication, and is inclined to neglect oiling his machine. If he is taught what proper lubrication means he may possibly pour in a pint or so of oil or grease if he can conveniently get it. Many miners, who have been continually told about oiling up, will use anything they can readily get hold of —from engine oil to cable coating—unless containers and proper grease be provided. Miners who do not know should be trained how to use the right amount of the proper lubricant and the frequency with which parts should be lubricated. Convenient pocket containers should be provided, and the bulk grease supply should be so placed that every miner who uses a rock drill can easily get enough to see him through a shift. Large containers that cannot be carried in the pocket should be avoided, because much grease is wasted by their use and more or less dirt gets into them.

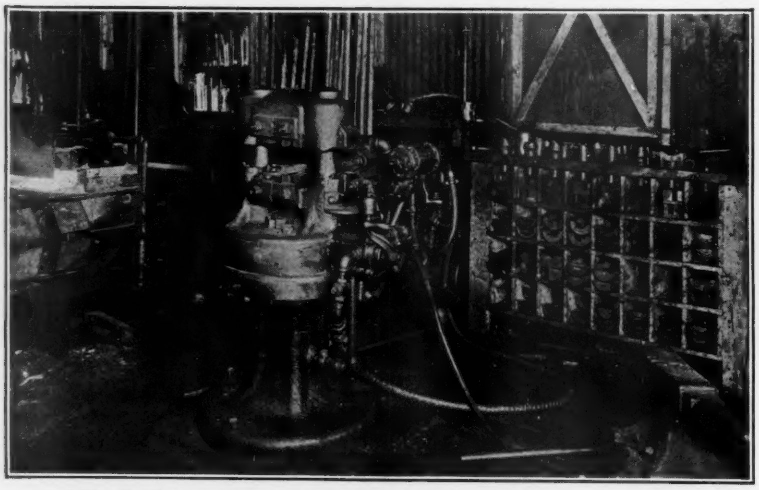
In general, it can be said that poor or insufficient lubrication causes rapid wearing of parts, resulting in leaks and in falling off of drilling efficiency. Due to rapid wear, the cost of replacement of parts runs high. The average person, and even a drill repair man, has no means of telling just what parts are worn beyond efficient working limits, and it will often be found that the wrong parts have been replaced while those that still have some life ahead of them have been thrown onto the scrap pile. This can be illustrated by the replacement of valves, which, in nine cases out of ten, are not to blame for sluggish machines. The parts which form the joints both in front and to the rear of the piston are usually responsible, and leaks there can be charged di-





rectly to faulty lubrication. The throwing of valves, or the reversing of the stroke in both the valve or valves types of machine, depends upon the air cushion at either end of the stroke; and the "pep" of the machine varies proportionately with the fit of the joints which seal this compression area.

When a drill bit binds in a hole, and the machine does not rotate the steel steadily, the cause can be traced to two things—poor drill bits or lack of lubrication. An experienced operator can immediately determine which one is to blame for the binding steel, and acts accordingly. To the inexperienced or untrained operator but one course is open—that of pounding the drill steel, which he does with any heavy tool handy. By pounding the drill steel, the steel, together with the front end parts of the machine, are broken. An application of grease would prevent this trouble in many cases.



A No. 5 "Leyner" Sharpener and the dies and dollies used with it.

The proper sizes of pipe lines, naturally, have much to do with the efficient operation of pneumatic rock drills. In installing pipe lines, it should be remembered that the main object of such pipe lines is to supply sufficient air to the machines and not to economize in the size of pipe.

Heavy drifters call for 1-inch air hose and ½-inch water hose. Sinkers, stopers, and light drifters require ¾-inch air hose. These sizes have been carefully worked out by accurate tests, and nothing smaller than the given sizes should ever be used. As an illustration, it has been proved that the free drilling speed of a "Jackhamer" falls off 30 per cent. when using a ½-inch air hose instead of the standard ¾-inch. This loss is due to friction in the hose. The size of a pipe line should always be sufficiently large to take care of the number of machines to be run from that line. In long drifts, or to remote parts of the mine where any amount of drilling is to be done, the size of the lines should be large enough to compensate for friction.

From time to time it would be well to connect a tested gage to the ends of the hose to determine the pressure at all points. Not less than 80 pounds pressure should ever be carried at any outlet if effective drilling is to be done. Another good thing is to occasionally place a gage between the end of the pipe line and the machine, as a means of checking up and of assuring sufficient pressure at the drill; and to take readings every fifteen minutes for several hours while the machine is in operation.

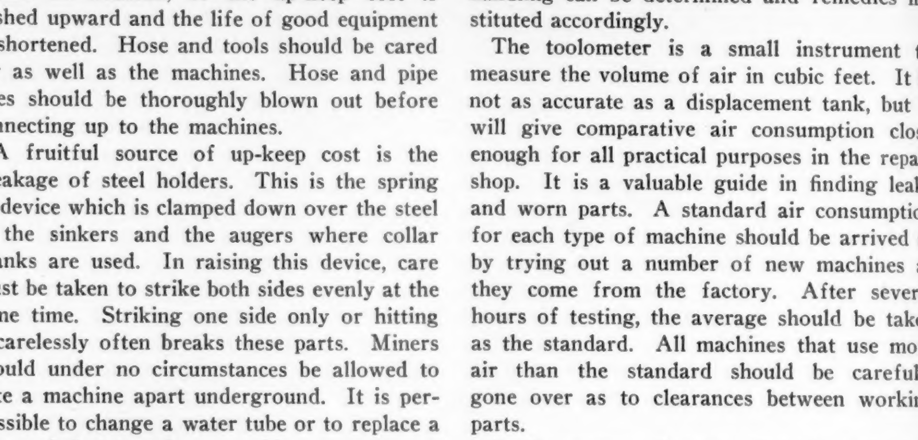
Drill machines should have good care underground and, at the end of a drill period, should be hung up or placed in suitable boxes. While lying idle, inlets should be stuffed with waste or paper, or a suitable cap should be provided to keep dirt and grit out of the working parts. When machines are carelessly thrown about along the sides of a drift, cranks are bent and broken, throttle handles suffer, and dirt and grit get inside. Many miners are prone to be careless in this direction and should be checked, or the up-keep cost is pushed upward and the life of good equipment is shortened. Hose and tools should be cared for as well as the machines. Hose and pipe lines should be thoroughly blown out before connecting up to the machines.

A fruitful source of up-keep cost is the breakage of steel holders. This is the spring or device which is clamped down over the steel in the sinkers and the augers where collar shanks are used. In raising this device, care must be taken to strike both sides evenly at the same time. Striking one side only or hitting it carelessly often breaks these parts. Miners should under no circumstances be allowed to take a machine apart underground. It is permissible to change a water tube or to replace a side rod, but to take a machine apart means running the risk of reassembling a lot of grit with the parts. A reasonable number of machines should be held in reserve at convenient places. These spares should be kept full of grease and in protecting boxes hung up between the timbers. It is also advisable to see that each drill comes to the shop once in two months, at least, if for nothing more than a thorough cleaning.

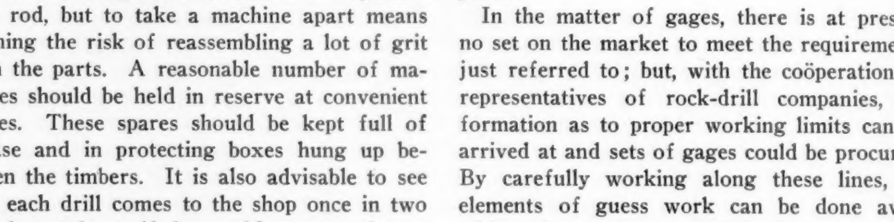
In order to prevent needless delays, every mine should maintain a well-equipped repair shop where first-class work can be done. One of our illustrations shows how such a shop should be laid out. A card index should be used to keep track of repairs. All drills should be stamped with a mine number. One way of numbering is to divide machines into classes: D—drifters; J—sinkers; A—augers; S—stopers, etc. The letter should be followed by the mine number of the drill. To make this plain, we are reproducing such a reference card, as used by an up-to-date mining company. Such a card will give the complete life history of a drill, and from it accurate costs can be compiled. Some matters relating to underground handling can be determined and remedies instituted accordingly.

The toolometer is a small instrument to measure the volume of air in cubic feet. It is not as accurate as a displacement tank, but it will give comparative air consumption close enough for all practical purposes in the repair shop. It is a valuable guide in finding leaks and worn parts. A standard air consumption for each type of machine should be arrived at by trying out a number of new machines as they come from the factory. After several hours of testing, the average should be taken as the standard. All machines that use more air than the standard should be carefully gone over as to clearances between working parts.

In the matter of gages, there is at present no set on the market to meet the requirements just referred to; but, with the coöperation of representatives of rock-drill companies, information as to proper working limits can be arrived at and sets of gages could be procured. By carefully working along these lines, all elements of guess work can be done away with and equipment could be kept up to its proper standard, at the same time saving many parts. There is more time lost by using worn equipment than by machine breakdowns. There-



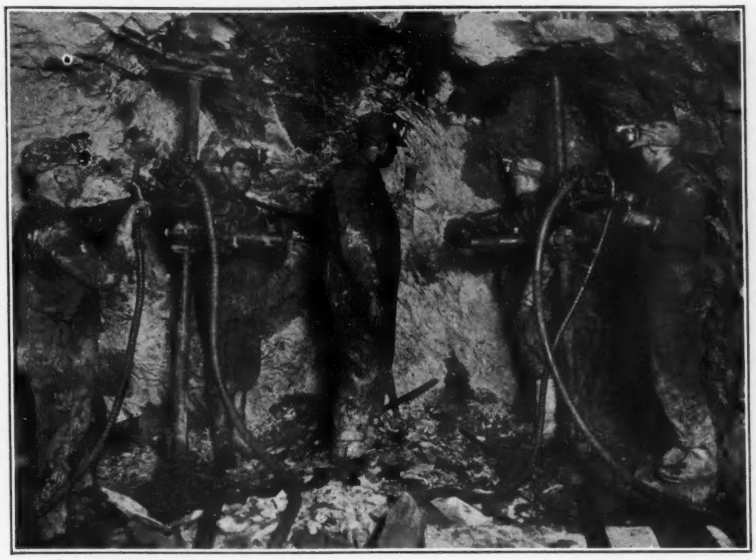
Don't depend on your eyes. Try end of shank with a small square.



When the piston striking edge is cupped it should be ground off square, taking care not to remove more material than is absolutely necessary. If this is not done the corners will be chipped off as shown above.

fore, the elimination of worn equipment should be considered as far as practicable.

When is a drill worn out? This is the most difficult question of all to answer unless actual figures are at hand. Common practice is to discard a part of a drill when it feels wobbly in or over another part with which it works. No means are at hand to determine the amount of wear accurately. This is where the gages help us. It is a fact that many parts are thrown aside which could be used a great deal longer, and that many parts are still in use that should be on the scrape pile. Also, every warehouse has its boneyard of new drill parts which will never be used—which represent a dead loss. These parts have been bought on the strength of the assumption that certain parts would wear out; and a definite number of each part is ordered on the supposition that every part has a certain life. How long that life is we do not definitely know.



Two "Leyner" drifters driving a 7x10-foot tunnel in a coal mine.

The life of a machine should be based on actual hours of operation. By allowing a machine to lie in the mine unused and full of moisture all parts become badly rusted. One rusting of this kind takes more out of a machine than six months of continuous service with the drill properly lubricated. Machines not in use should be put away full of grease. When properly lubricated and cared for, a machine should give good and efficient service for about two and one-half years before showing any great falling off in drilling capacity and an excessive air consumption. After two years of continuous service it should be closely watched and timed as to drilling speed and air consumption and compared with a new machine. It will then be possible to get definite figures in terms of dollars and cents, and to establish whether it is cheaper to take the machine out of service, salvaging a few parts after gaging, or to replace it with an entirely new machine. The parts which come within the working limits can be used to replace broken parts of other drills. For two years, with proper use, it should not be necessary to replace a single part, aside from pawls, on account of wear. By placing new machines in service from time to time, new life is added to drilling equipment, and an over-stock of spare parts is avoided.

When should a rock drill be replaced by a new unit? In order to answer this question, accurate figures are necessary. The following data were taken from actual working conditions at a large mine:

In the case of six new drills, over a period of 442 working days, each drill came in for repairs on an average every 49 working days. The average cost per drill per month of 26 working days, for repair parts only, was $6.35. The records of three other drills, which had two years and three months service previous to taking records, show that over a period of 416 days each drill came in for repairs on an average every sixteen working days. The average cost per drill per month for repair parts only was $31.66.

Let us suppose a drill costs $300. At that rate, by scrapping the three old machines which had given two years and three months service, we could purchase three new machines and also pay for the necessary repair parts to keep these units running for one year.

This does not take into consideration the advantage of sending a machine to the shop and back into the mine every 49 days instead of every sixteen days, or the reduction of time lost in changing machines. Then on top of these benefits there is the saving of air due to new equipment; and, finally, the greatest item of all—that of drilling speed of new as compared to old machines. By working along the lines suggested and scrapping the old machine it has paid for a new drill and its up-keep for a year. Besides, there is more than a year of efficient life ahead of the new machine, the drilling speed of which, as against the old drill, would no doubt buy another new machine.

Sample drill Repair Card
any card index size

MINE No. TYPE. PLACED IN SERVICE Jan. 1,22 new machine
CYLINDER No. 372641 Jan. 1, 22 TEST 80 lb. air 98 cu. ft. per min

Date in Shop	REPAIRS	TIME	REMARKS	TIME	PRESS.	Cu.Ft	ROTA'N	DATE OUT OF SHOP
Feb. 1, 22	1 Front chuck bushing cleaned	1 hr.	very dirty	5 min	80 lb.	100	good	Feb. 22
Mar. 16, 22	dirt in valve cleaned	1 hr.	very dirty	10 min	84 lb.	103	good	Mar. 17/22
	etc.							

The following tabulation is based on the foregoing figures and on one machine:

Repair cost on one old machine $31.66 per month for 12 months		$379.92
Cost of one new machine (cost at time figures were taken)	$300.00	
Repair cost on one new drill $6.35 per month for 12 months	76.20	
Total cost of new machine and its upkeep for first year's operation		376 20
Loss represented in cost of repair parts only		$3.72

As a general rule, several different makes and a dozen different types of drills are in use and disuse around every mine. There is also a corresponding number of parts in every warehouse, some of which are useful and some of which are obsolete and, therefore, a dead loss. In many cases, such conditions do not pay for the small amount of gain, say 5 or 10 per cent., in drilling speed, as might be shown in a 2-weeks' test. Where such conditions exist, none of the drills in use is really kept up to its efficient standard. As a general thing, it is better to sacrifice 20 per cent. of ultimate drilling efficiency for a 10 per cent. gain shown in a few weeks' test. This is an absolute fact, and if conditions are thoroughly gone into it will be apparent that such is the case when a great number of different makes, types, and sizes of machines is in use. The mining company in question would be farther ahead at the end of two years if it took the most inferior machine on the market, and equipped its mine with it throughout, and kept that type up to its factory standard than if it installed a few of each of the superior types and only half maintained them. And, further, there would be a smaller loss on repair parts in the end, counting unused parts left in the warehouse. A type or make of machine cannot establish its superiority in less than six months; and the drilling speed and the upkeep costs should be based upon actual hours of operation. Furthermore, new machines of each type should be started upon an equal basis. Comparison should not be made between a new machine of one type and an old, used machine of another.

It is impossible to secure greatest efficiency

with drilling equipment unless one knows exactly, in terms of work and dollars, what that equipment is doing and what the upkeep amounts to. The foregoing paragraphs merely show wherein money may be gained or lost, with general suggestions and remedies.

In order to reach the highest point of efficiency, the miner, as well as the repairman, must do his part. The miner, however, cannot be blamed if he should by chance do something detrimental to a rock drill. Perhaps he has never been properly instructed in the care and the maintenance of such a machine, and he should, therefore, be given proper training. It is often his natural tendency to plan his work only for the day, and in doing so, as long as he has tools for that day, he does not look farther ahead except, occasionally, to hide good tools intending to use them again the next day. These hidden tools are sometimes lost. If a miner knows that he can always find a first-class machine in his place he will not hide the only good one he can get hold of. He must not only be trained to take care of such equipment, but he must be shown how to get the most out of it. Good tools make his work easier, for one thing, and, in the end, more is accomplished. It would be out of the scope of this discussion to cover each special condition. The aforementioned facts are given as a working basis.

The number of various subjects touched upon is by no means complete, and does not begin to reach the limits of rock-drill operation. The facts as outlined are statements of experiences in the course of regular underground work. There is much more to be worked out along these lines, and, in doing so, the efforts put forth would surely be more than compensated by the returns from efficient rock-drill operation and maintenance.

HIGH-PRESSURE STEAM

The Ohio Power Company is preparing plans for a power station to be erected on the Muskingum River at Philo, Ohio. There are to be two 35,000-kilowatt General Electric turbines, which will be operated at 530 pounds steam pressure and at a total temperature of 725° F. at the turbine throttle. The Babcock & Wilcox boilers will be built for 650 pounds working pressure. Superheaters and economizers are features of each unit.

The indications are that the people in the United States are going to consume 350,000,000 gallons of ice cream this year. Even at that, 3.2 gallons per person for a period of 365 days does not seem like so large a portion. However, the popularity of ice cream is growing so fast that it is confidently expected that 500,000,000 gallons will be demanded here within the next five years. This increased production will call for a big expansion of the plants now engaged in the business.

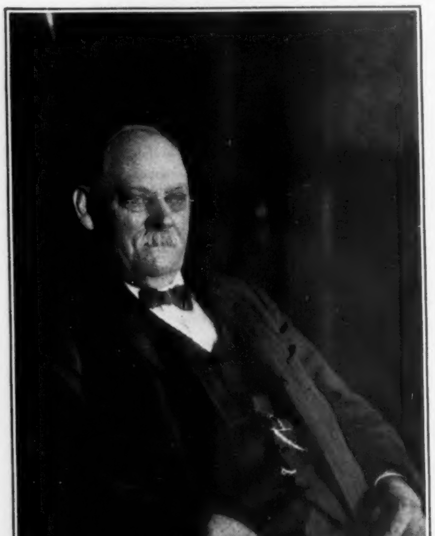
During the eleven months ending November 30, 1921, there were drilled 231 oil wells in Mexico. Of these, 61 per cent. have turned out producers while the remaining 90 wells have been abandoned. This is a very good showing.

THE DEATH OF JOHN HICKEY

THE DEATH of John Hickey in New York on April 7, 1923, calls attention to the life of a mechanic covering a period of more than 50 years. During all that time he was in the service of individuals and companies engaged in the development of the rock drill and the air compressor.

Beginning in 1871 as a machinist with Sergeant & Cullingworth, in a small machine shop on 22nd Street and Second Avenue, New York, he died in the service of the Ingersoll-Rand Company, being active up to a few days before his death. It is interesting to note that the funeral service was held in the Church of the Epiphany, almost directly opposite the site of the old shops of the Ingersoll Company where the rock drill was born.

He was born in Ireland on February 10, 1847; and though he had an impulsive temperament yet his nature was so kindly and sympathetic that he won the love and affection of his associates. His life covers the history of the rock drill and the air compressor. Simon Ingersoll invented the drill about 1871—the same year the Rand Drill Company was organized; and though various experiments and machines of different kinds had been tried prior to that date, yet the practical application of the rock drill began with Hickey's entrance into the shop where the first Ingersoll drill was brought to be repaired.



John Hickey

Hickey started in as a day workman and mechanic, but showing ability and faithfulness of service he was in due course advanced to be foreman of the compressor department of the Ingersoll Rock Drill Company, successor to the Sergeant & Cullingworth Company. In 1886 the Ingersoll Rock Drill Company's shops were moved to 9th Avenue and 27th Street, where Hickey served for some years in charge of the air compressor department. This service he performed during the period when the compressor was going through a stage of development. At first it was a machine with two simple cylinders—one for air and the other for steam, with a fly wheel, valves, and other mechanism.

At the beginning these machines were used exclusively for tunnel work, because of the high cost of compressed air when produced by simple slide-valve engines without compounding. Hickey built the straight line and afterwards the compound machines, and became an expert in the construction and use of compressed air machinery. The Ingersoll Rock Drill Company subsequently became the Ingersoll-Sergeant Drill Company, and in 1905 was merged with the Rand Drill Company under the name Ingersoll-Rand Company.

Before this merger it became necessary for the Ingersoll-Sergeant Drill Company to move its shops from New York to Easton, Pa., inasmuch as the building of air compressors and other machinery had developed greatly and some of the machines were of such large sizes that it was thought best to construct them out in the country. Hickey went to Easton for a time, then took a trip to Ireland. On his return he came to the New York office of the Ingersoll-Sergeant Drill Company, where he acted as mechanical expert, and in which position he served until his death.

John Hickey's value in the office was due to his long experience in the shops, which fitted him to go out into the field and to overcome troubles, and to educate younger men in the practical design and application of Ingersoll-Rand machinery. Salesmen and others, when stumped on some question of mechanics, would go to John Hickey as to a dictionary.

In June, 1920, there was celebrated in the New York office of the Ingersoll-Rand Company the 50th anniversary of Hickey's service with the Company. The chairman of the board, the president, vice-presidents, treasurer, managers of shops, mechanics, and clerks, to the number of several hundred, gathered in the main corridor to do him honor. He was presented with a beautifully engrossed memorial signed by the officers and scores of the employees, and a check for a substantial sum was also given him. To newspaper reporters, on that occasion, Hickey made this interesting statement about the labor situation:

"This attitude of labor is all wrong. Stick by your boss and he will stick by you. My experience has proved this. The men you work for will be fair to you if you play fair with them.

"I've loved machines ever since I could walk. I've never earned a dollar in my life except by my work with machines. I feel towards 'em just the way a mother feels about her baby."

Here was a man who started out as a plain, uneducated mechanic, but who had all the instincts of nobility, was faithful to his employers, always at work, striving to serve, and winning golden opinions from all that came in contact with him. He got his reward through the success of the machinery upon which he worked; and this contributed largely to the prosperity of the companies that employed him. He died in comfortable circumstances, happy in the thought that his life had not been lived in vain.

The Kent Coal Fields are England's Newest Source of Fuel

The Discovery of These Deeply Placed Coal Measures is the Outcome of Scientific Reasoning on the Part of Geologists

By ROLAND H. BRIGGS

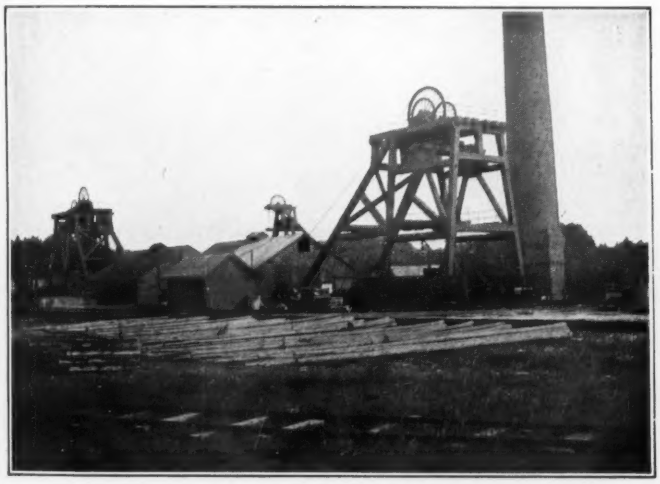
THE KENT coal field is unique among the coal fields of Great Britain. It is far away from any of the other English coal areas, and was found by borings after scientific reasoning had shown the probability of coal being located there. At no point do the coal formations crop out or come anywhere near the surface; and the discovery of the field may be regarded as one of the greatest triumphs of the application of theoretical geology. The section is also rich in ironstone; and it is, indeed, difficult to believe that an area, so noted in the past for its orchards, hop gardens, and pastoral beauty as to be called the "Garden of England," will most assuredly become in the comparatively near future a great coal, steel, and iron center.

Although many years have elapsed since the first disclosures with regard to Kent coal were made—its existence was proved in 1890—it is only at the present time that the productive prospects have brought the field within the category of a commercial coal area. Even in 1909, important newspapers referred to the Kent coal field in the following terms.

"While on the subject of rubbish, I may mention that Kent Collieries today experienced their final spasm, dropping from 1. 6d. to the nominal price of 3d. Thus ends the lamentable history of the attempt to convert the Garden of England into a second Black Country." Another paper said: "The enterprise must unfortunately now be regarded as something less than a forlorn hope. By good authorities the Kent coal experiment is now regarded as unsuccessfully completed." But thirteen years later, these same newspapers are publishing the weekly outputs of the collieries in Kent: Chislet, 5,000 tons; Tilmanstone, 4,000 tons; and Snowdown, over 3,000 tons per week. At the time this article was written operations at the latter place were restricted owing to developmental work.

Very important developments are foreshadowed by the announcement that Messrs. Dorman, Long & Company, Ltd., the great coal, iron, and steel producers and constructional engineers of Middlesborough, have largely added to the interests which they already have in the field by the purchase of an additional 20,000 acres from several of the Kent coal companies. It is understood that they will work both the coal and the ironstone; and this section of England will, undoubtedly, soon be one of the steel producing centers of the world.

The generation which has elapsed between the actual finding of coal in Kent and the development of the field to a point of reasonable commercial production has been spent in overcoming the three main sources of trouble with which the promoters have had to contend. The first was a financial question; the second was the type of coal found; and the third the large quantities of water encountered.



Head gears and surface works at Guilford colliery.

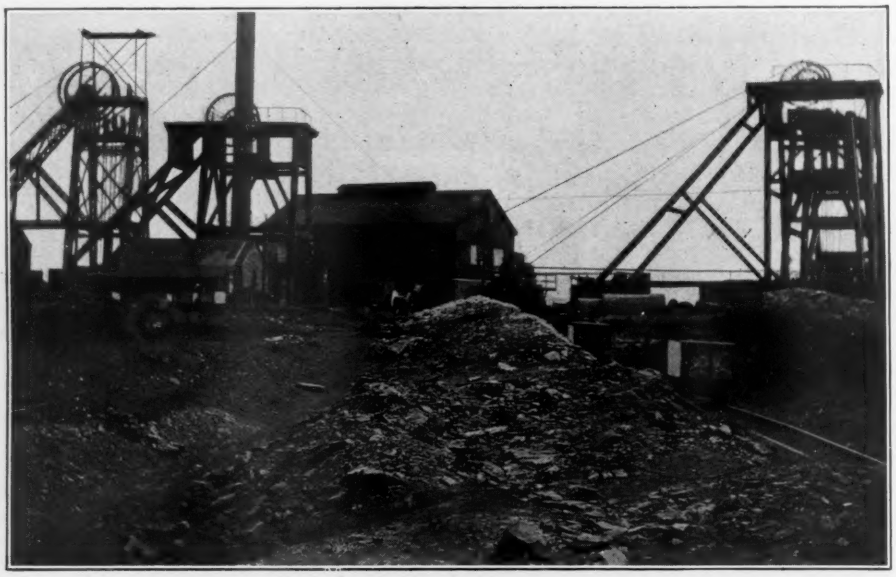
General view of Stonehall colliery.

The financial story of the Kent coal field may be briefly told—it consisted of too much money at the beginning and too little at the end. Never did the public lose its head more completely than in the early days of Kent coal. Coal to the average Britisher is simply a black, lumpy substance which is burned in an open fireplace. The typical Londoner at once measured the distance between London and Kent with a pair of pocket compasses and, next, figured out how far the other coal fields were away. Then he realized that this new El Dorado was but half or a quarter of the distance of the other fields from London. He put his compasses in his pocket, ran to his broker, and told him to buy, buy anything with the name of Kent on it, and then went home with visions of roaring fireplaces, filled with great lumps of coal, and of golden guineas pouring into his bank account. He and thousands like him have lived to regret that day.

In due course reaction came. Companies were organized and reorganized with startling rapidity. Most contradictory reports were received from the different interests, but the one thing certain was that very little coal and no dividends were forthcoming. Gradually, the public swung to the opposite extreme and said, as they still do, "Is there really any coal in Kent?"

The second reason for the difficulties of the Kent colliery proprietors is that most of the coal mined there at present is excellent steam and bunker coal, with good coking properties, but not house coal. There is house coal, however, but so far steam coal forms much the major part of the output. This, naturally, robs the nearness of the field to the London market of some of its value, but this point will become of less and less importance as the extravagant way of burning raw coal in an open fireplace in England gradually dies out.

In connection with the third source of trouble—the large quantities of water tapped during the sinking and the working of the mine—it may be said that this difficulty does not present any features which are insurmountable to the engineer. At the Chislet colliery it was overcome by sinking the shafts by the cementation process—a process by which sediments or sands are consolidated into hard rock; and various other methods have been employed to counteract the water at Tilmanstone and elsewhere. Those who are interested in the manner in which the underground waters of the Kent coal field were dealt with should refer to the excellent treatise on the subject read by Mr. E. O. Forster Brown at the Institution of Civil Engineers, November 22, 1922.



Tilmanstone colliery.

The first intimation of the possibility of coal in Kent was made in 1846 by Sir Henry de la Beche; but the matter was lifted to the stage of probability in 1855 by the famous paper of R. A. C. Godwin-Austen. A borehole was put down in 1872 without results; but the matter remained of great interest not only to British but also to French and German geologists. In 1890 a new borehole, at the foot of Shakspere's Cliff near Dover, struck the coal measures at a depth of 1,157 feet, and then passed through seven seams of coal, each exceeding two feet in thickness, before the borehole was stopped 2,330 feet down. The largest seam is four feet in thickness. From that time forward very many borings have been put down in Kent; and the limits of the field have been approximately determined.

As far as is now known, the Kent coal field, roughly speaking, lies within a line drawn due west through Ramsgate intersecting a line drawn due north and south of Canterbury. The field undoubtedly extends for a certain distance underneath the sea. The collieries constructed up to date are: Shakspere's Cliff, Tilmanstone, Snowdown, Guilford, Stonehall, and Chislet. Of these Shakspere's Cliff is "dead," although it will probably be worked as an ironstone mine, and Guilford and Stonehall are not yet producing.

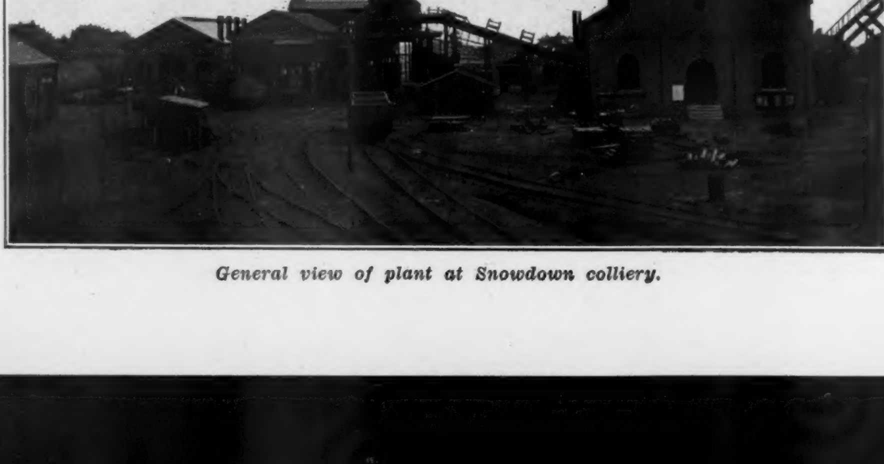
Shakspere colliery was the first, and it was located on the site of the successful borehole previously mentioned. It is stated that £1,000,000 was spent there in a futile effort to produce a working colliery. The first shaft was sunk to a depth of 366 feet when there was so serious an inrush of water that sinking had to be abandoned. In sinking the second shaft a sudden inflow of water at 303 feet resulted in eight out of fourteen men working at the bottom of the shaft being drowned. Eventually, No. 2 shaft was sunk to 1,662 feet and No. 3 shaft to 1,632 feet; but the coal produced was not even equal to the requirements of the colliery, itself. The only coal shipped was a consignment of 120 tons for test purposes. Water difficulties were continuous; and, subsequently, the colliery was abandoned as a coal mine; the two shafts were plugged with concrete at a point below the iron ore stratum; and in future only ironstone, found at 611 feet, will be taken from this mine.

The story of Tilmanstone colliery also reveals much trouble with water, but methods were found to meet the situation which had to be faced. A steady output from this mine has been maintained since the first raising of coal in 1913, and more than 1,000,000 tons have already been produced. The sinking of a preliminary shaft was begun at Tilmanstone in 1906, but so great were the difficulties experienced—chiefly due to a shortage of cash and an excess of water—that the shafts were not completed until 1913. Water at a pressure of at least 500 pounds per square inch had to be dealt with at Tilmanstone, and the sandbed, which is the source of most of the trouble, still delivers a total supply of about 1,650 gallons per minute from all three shafts. This the pumps have to take care of.

A pumping station was installed at the 1,140-foot level in the oölitic limestone and connected with all three shafts. The writer saw the electric-driven centrifugal pumps in this underground station when he descended the mine to view the coal face of the 5-foot seam, 1,548 feet below surface level, from which the present output of the colliery is drawn. Energy is obtained from the electric power plant at the surface; but even with this efficient equipment the cost of pumping is a serious item in the mine expenditures. The power house contains two Westinghouse turbo-alternators, giving 1,200 kilowatts when condensing and producing 3-phase current at 3,300 volts, 50 periods. Compressed air is supplied by an electric-driven compressor; and ventilating air is obtained from a 60-inch Sirocco fan.

From Tilmanstone we may pass to Snowdown which, indeed, claims priority in the matter of the first coal raised. Sinking was begun there in 1906, but by 1908 there were just two shafts, 300 feet deep, one of which was waterlogged and, therefore, abandoned. A third pit was sunk to replace the first, but sinking the second and the third pits had only reached 917 feet in 1911 when a stoppage was made to erect a plant to deal with the expected water difficulties. The first hoppet of coal was brought up in November, 1912; and the shafts entered the Beresford seam, four feet four inches, in 1913. The Beresford seam yields a fine gas and steam coal, but it is of rather a friable nature. At 3,007 feet there is a 4-foot 5-inch seam of hard coal, and this will probably give a better return to the promoters for the work done. Shafts Nos. 2 and 3 are now 3,020 and 2,287 feet deep, respectively. Like Tilmanstone, this colliery has also a fine electric power house as well as efficient electric and steam pumping equipment to deal with the water. Compressed air at 80 pounds pressure is provided by an Ingersoll-Rand compressor, having a capacity of 500 cubic feet per minute, and is used to drive rock drills in shaft sinking, small inby pumps, and for the blacksmith's blast.

The Guilford colliery, which has three shafts, was idle when the writer visited it. One of the shafts is really only a 12-foot water hole, 309 feet deep, but the other two, begun in 1906, are eighteen feet in diameter. One shaft is al-

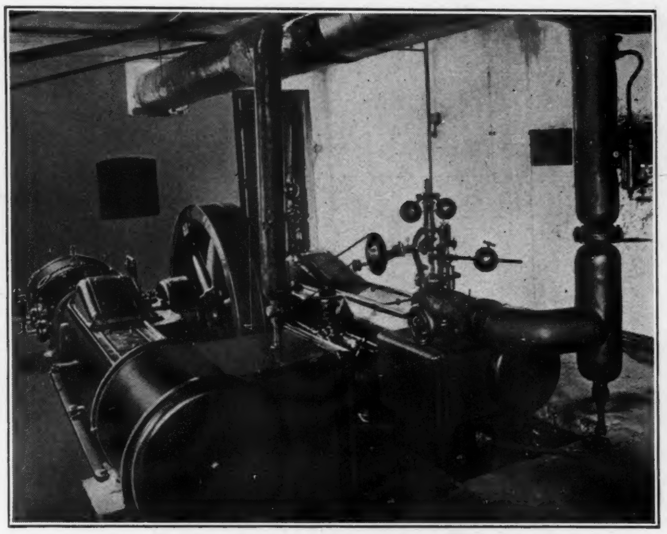


General view of plant at Snowdown colliery.

most down to the coal measures. This colliery is equipped with winding engines, pumping equipment, and an "Imperial" type X-3 air compressor with compound steam and compound air cylinders, having a capacity of 600 cubic feet of free air per minute, which supplies power for pneumatic rock drills.

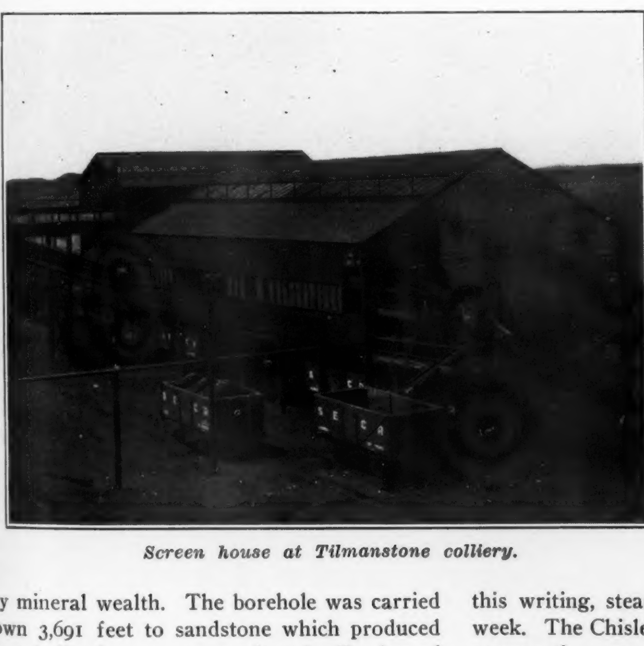
Just over the hill from the Guilford colliery lies the Stonehall colliery, which is in

One of the picking screens at Snowdown colliery.

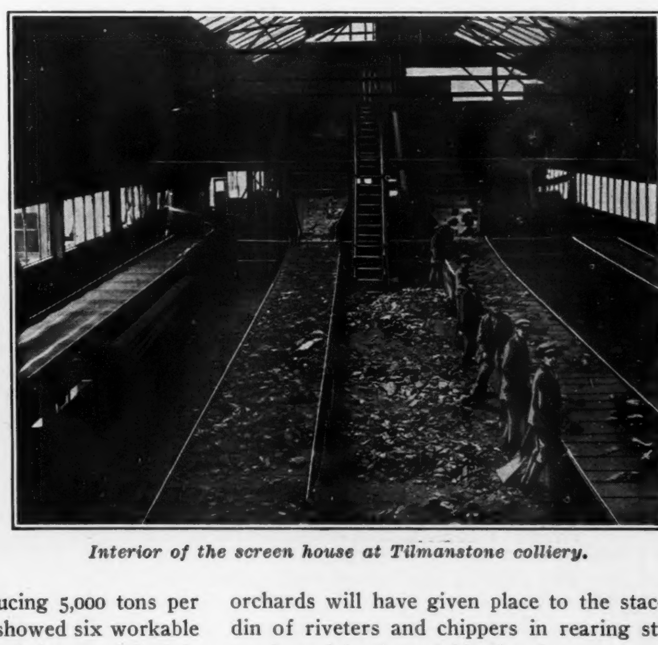


Steam-driven air compressor at Guilford colliery

an even less advanced condition than the Guilford mine. A good deal of preliminary work was done on the surface in the running of railway connections to the main line; in the erecting of buildings and equipment; and in sinking shafts. Since the outbreak of the war, when this work was in progress, no further advance has been made. But a borehole put down on this site revealed quite an extraordin-



Screen house at Tilmanstone colliery.



Interior of the screen house at Tilmanstone colliery.

ary mineral wealth. The borehole was carried down 3,691 feet to sandstone which produced cores indicating 21 seams of coal. Twelve of these were from six to nine feet in thickness. It has been suggested that there may exist overthrow folds, in which event the borehole might have penetrated some of the seams more than once; but the general geological features of the coal field do not give much support to such a contention. In any case, the results of this borehole alone should be sufficient to silence the Doubting Thomases who still question the existence of coal in Kent. The last two seams penetrated were eight feet seven inches and nine feet thick. Collieries have also been begun at Wingham and Hemel.

Although over 40 boreholes have now been put down in Kent and much activity again prevails there, the five collieries described in this article, two of which are producing, are all that the southern and the central parts of this coal field have so far brought into being; but at the northernmost extremity there is another colliery toward which all eyes have been directed during the past few months. This is Chislet, which has rapidly caught up and surpassed the output of Tilmanstone, and is, at this writing, steadily producing 5,000 tons per week. The Chislet boring showed six workable seams: the one at present being exploited is four feet six inches thick and at a depth of 1,350 feet. The coal measures are entered at 1,115 feet.

The water-bearing strata present in the central part of the coal field are absent at Chislet; but there was a good deal of water in the upper chalk, and a considerable layer of running sand had to be dealt with. These difficulties were overcome by the cementation process, work on which was started in 1914. Production from this colliery did not begin until well after the war was over, but the satisfactory output has done much to place this new coal field on what might be termed a commercial basis.

This is the story of the Kent coal field up to the close of 1922. The initial developmental work has been done—the worst phase of the exploratory operations have been completed, and the industry is expected to be of great benefit to Britain. Within 40 years from the sinking of the first borehole, billets and blooms of Kentish steel will be available for the engineer; and the hum of bees in the erstwhile orchards will have given place to the staccato din of riveters and chippers in rearing structural steel in the neighborhood.

In conclusion, the writer desires to express his appreciation of the assistance rendered in the preparation of this article by Mr. A. E. Ritchie, Director of the Snowdown Colliery, Ltd., and the managers of the various collieries described.

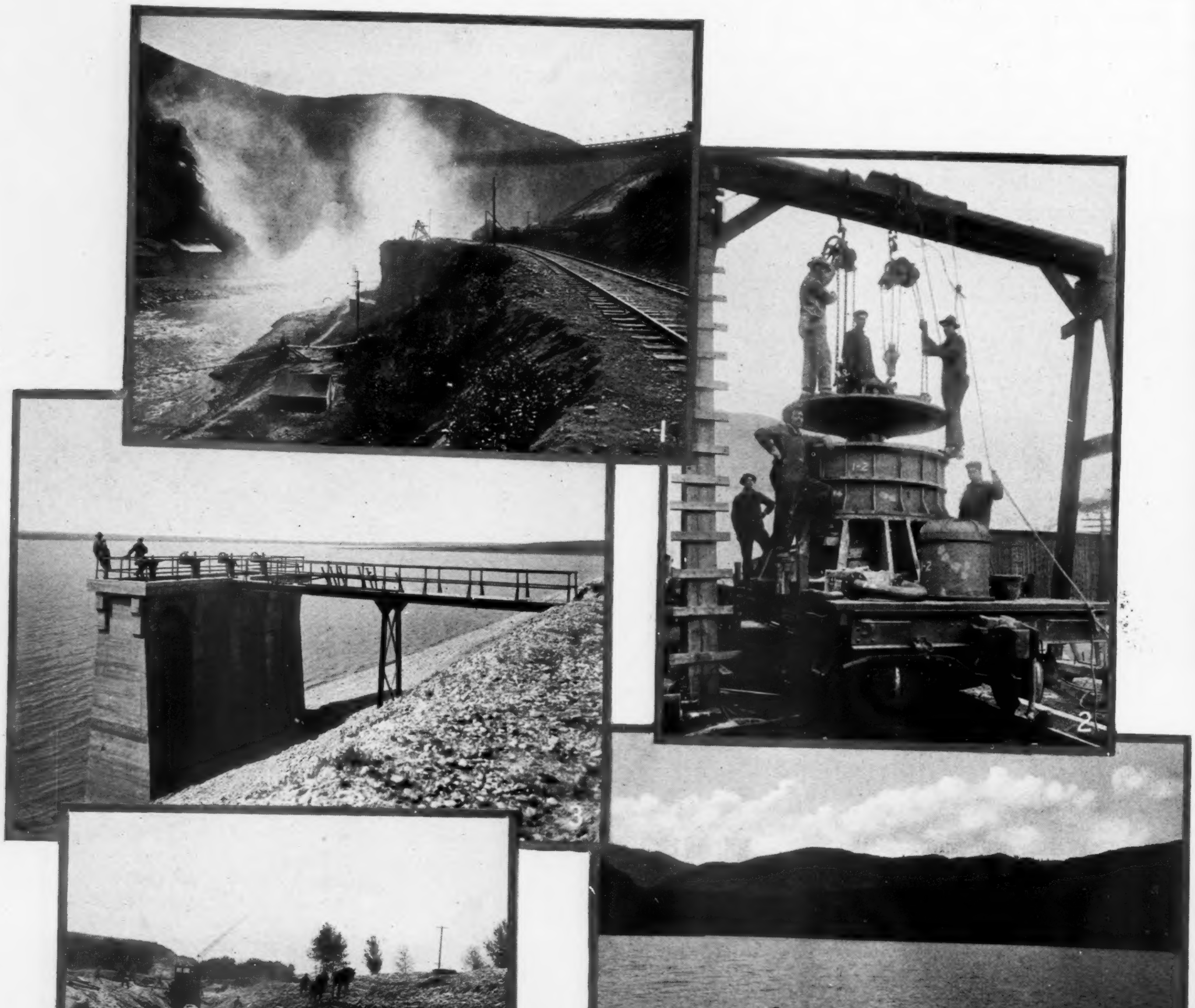


Fig. 1—The Arrowrock Dam from the down-stream side. Fig. 2—Dismantling a 58-inch control valve preparatory to installing it in the dam. Fig. 3—Outlet gates in the north side of the embankment at Deer Fleet reservoir. Fig. 4—A portion of the reservoir on the up-stream side of Arrowrock Dam. Fig. 5—A reinforced concrete aqueduct forming part of the great irrigating system. Fig. 6—The spillway and abutment of Arrowrock Dam. The water is being discharged under a head of 70 feet and is falling 150 feet to the river bed below.

Patching the World's Highest Dam By Means of Compressed Air

By S. R. WINTERS

COMPRESSED air was instrumental in building and is now an agency in repairing the Arrowrock Dam, the highest structure of its kind in the world, towering 351 feet above its bedrock foundation. Gunite, a mixture of Portland cement and sand, is being sprayed on the disintegrating concrete of the main canal of the immense reservoir, formed by the dam, by means of cement guns, operated by compressed air. A report by the engineer of the Boise reclamation project, located in Idaho and Oregon, is suggestive of the value of gunite and the future application of compressed air equipment in patching up the canals of the nation's widespread irrigation systems. This official document reads, in part, as follows:

"The original installation of the concrete lining on the main canal has deteriorated considerably and a great deal of work has been undertaken in relining with gunite over the old work, and much more of this class of work must be done in the future in order to preserve the old lining on the main canal."

Experiments in the application of gunite to concrete water-carrying channels, begun in 1918, were successfully continued during the fall months of each succeeding year. When this work of fortifying the main canal of the Arrowrock Dam was first begun, much of the lining of the channel was cracked and disintegrated. The initial application of gunite was effected over a period of two months in the fall of the year, when the water could be conveniently turned out of the canal. All told, during the first year, 6,300 yards of gunite was sprayed on top of the old lining of the channel at a cost of fourteen cents a yard, an expenditure less than that entailed in doing similar patchwork in a less efficient way.

An Ingersoll-Rand air compressor, operated by an electric motor, was employed for the purpose of mending Uncle Sam's huge ditch. Two cement guns were kept on the job continuously and were operated at an air pressure of from twenty to 25 pounds. The coating thus applied covered the original concrete to a depth of 1½ inches and has served to eliminate leaks and to avert breaks that threatened the integrity of the reservoir, whose storage capacity is sufficient to cover 280,000 acres of land with water to a depth of one foot.

The terrain was such as to discourage establishing a camp, with mess and bunkhouse, at the scene of activities. Hence, two Maxwell 1-ton motor trucks were engaged for the purpose of transporting the workmen to and from Boise, a distance of eight miles one way. The gunite used in reinforcing the lining was composed of one part cement and six parts of sand. The latter was divided into two components, three parts of coarse river sand and an equal proportion of fine sand. The labor costs are thus itemized; Foremen, $5.00 a day; nozzlemen operating cement guns, $3.80 a day; common laborers and teamsters, $3.60 a day; 1-ton motor truck and chauffeur, by contract, $12.00 a day. The sand was hauled one mile, and the equipment and materials for the operating plant were brought from a point eight miles distant.

The use of gunite in mending the leaks in the big artificial waterway has proved to be both economical in application and satisfactory in service. The engineer of the Boise reclamation project has written to the United States Department of the Interior that the "Work is successful and the cost is reasonable." The rôle played by compressed air in placing the concrete was somewhat difficult when relining was begun, three years ago, owing to the badly damaged state of the canal. Obviously, other units in the vast irrigation system of the Federal Government may be repaired from time to time by this method with less trouble, provided the work is not unduly postponed. The canals and laterals of the Boise reclamation project aggregate 989 miles, while the waste ditches and deep drains add another 200 miles to this net-work of waterways whereby barren acres have been transformed into fruitful lands. These figures give some idea of the extent of the relining to be done.

The usefulness of compressed air in reinforcing huge artificial ditches brings into review the conspicuous part played by this adaptable servant of mankind in building the highest dam in the world—the structure which it has recently been instrumental in making sound again. The site on which the Arrowrock Dam is located involved the excavation of 260,000 yards of loose material, earth, gravel, and boulders, as well as 470,000 yards of rock. The removal of these, as well as the actual construction of the great reservoir, made it expedient that a compressed air plant be established on the south bank of the Boise River at the scene of operations.

The equipment consisted of a 720-cubic foot capacity air compressor, connected to a 125-H.P. motor, and one 220-cubic foot capacity machine belt driven by a 40-H.P. motor. The latter unit was removed to the gravel pit when operations were begun, and in its stead a type 10 air compressor, of 520-cubic foot capacity, was installed. This machine was driven by a belt connected to a synchronous motor housed in the main air compressor plant. Air lines were run from the power plant to the diversion tunnel during its construction—compressed air being employed for drilling purposes. As the structural activities progressed, the air lines were extended to the points where excavations were to be made for the dam and the spillway. Here, too, pneumatic tools were used for drilling; while the air lines were linked with the machine and the blacksmith shops to operate blowers, riveting hammers, and other essential equipment. The plant for mixing the sand and the cement was supplied with air for blowing dust from the motors; for conveying cement to the mixing establishment; and for operating the gates of the measuring boxes. The power dumping gears on the mixers were early discarded, by reason of the expense incurred in making repairs, and an oscillating cylinder, actuated by compressed air, was utilized instead.

Compressed air was also employed in grouting the foundation and abutment keyways of this Goliath of dams. Compressed air furnished the power for the piston pump which was used in raising water to a storage tank from which it was drawn for sprinkling concrete and for similar purposes. The concrete was delivered by cableways, a method involving the use of receiving hoppers, located at convenient points. The gates of this concrete distribution system were controlled by compressed air. This same agent operated wood-boring machines; drilled steelwork in the field; cleaned the rock or concrete surfaces before fresh concrete was placed; and even blew whistles which warned workmen that loads of materials were being transported overhead. And, what is more, all these manifold services were performed at a cost of only $16,000!

This tallest of dams and its irrigation arteries for refreshing arid acres are located in southwestern Oregon, embracing Ada and Canyon Counties and extending into Malheur County. It lies between Boise River on the north and Snake River on the south, and is at an elevation of from 2,300 to 2,600 feet above sea level. It is the only source of water for an area of 140,000 acres, 110,000 of which are under cultivation. Eight commercial enterprises also tap this man-made reservoir for irrigating 108,942 acres. Alfalfa, wheat, corn, potatoes, and sugar beets are among the crops now grown in this formerly unproductive section of the country. The Arrowrock reservoir, so far as the runoff of the associate watershed is concerned, is not in keeping with the height of the dam, inasmuch as it generally holds only enough water to cover 280,000 acres to a depth of one foot. It has been full but once since its construction, six years ago, remaining so for a period of twenty days.

The main canal of the Boise reclamation project, where relining by means of compressed air is being effected, was designed for a capacity of 2,500 second-feet of water with an 8-foot depth and approximately 2,800 second-feet of water with an 8½-foot depth. The greatest discharge of this irrigation channel since its construction in 1915 was 2,400 second-feet, a record that was maintained for 30 days. The main canal, which diverts from the Boise River, eight miles above the town of Boise, and extends to the Deer Flat reservoir, another unit in this reclamation system, covers a distance of 40 miles. For a stretch of eight miles this canal follows the natural channel of Indian Creek. Above this point the channel is comprised of earth sections 70 feet wide at the bottom and having banks twelve feet in height. The diversion dam, located in Boise River, is of the overfall type, with a weir crest 400 feet long and a logway 30 feet wide.

Passing Hot Rivets by Means of a Breath of Air

By ROBERT G. SKERRETT

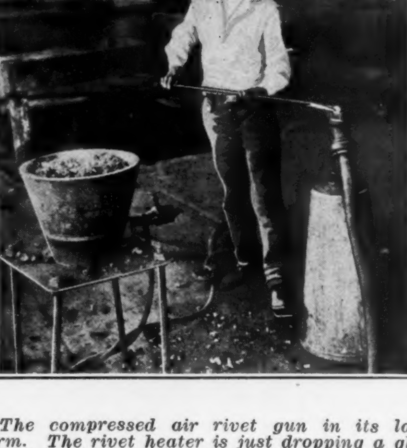
"DO IT pneumatically" is more than a catch word for the promotion of business. Each day compressed air is revealed in a new field of usefulness, and, as a rule, it does the work assigned it better than any other power or operative medium. Probably one of the most effective and novel uses of compressed air is that of passing rivets from the forge directly to the riveting gang at work perhaps scores of feet away and out of sight of the rivet heater.

The hand passing of red-hot rivets has long been a familiar spectacle wherever structural steelwork of any sort was under way. Time and again wondering spectators have watched a forgeman take with his tongs a rivet from its flaming bed and toss it confidently a considerable distance to a waiting lad, armed with a bucket or a handy can, who, after catching the rivet on the fly, would pass it thence to the riveting gang. How many of the marveling onlookers traced what followed when the passer failed to catch the glowing bit of steel? How many realized the number of injuries inflicted upon luckless persons when those searing missiles hit them instead of landing in the "catching can"?

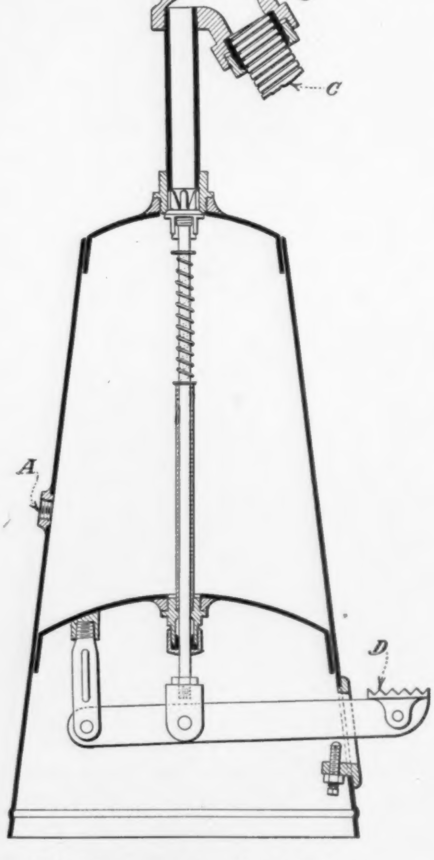
The records of every modern shipyard, the story of the erection of every skyscraper, and the casualty list of the building of every big bridge will be found fairly well filled with instances of bodily hurt or harm done by rivets that went astray in the passing. Not only that, but a misdirected rivet is seldom picked up soon enough to be used at the time, if used at all; and the hand passing of rivets undoubtedly cuts down efficiency and working speed. Realizing these various shortcomings, William B. Furman devised a pneumatic rivet-passing device and first put it in service at the yard of the Sun Shipbuilding Company in April of 1920.

The Furman rivet passer was the outcome of a realization of what might be gained if heated rivets could be delivered to isolated compartments so quickly that they would still be hot enough to be driven properly and to draw snugly together adjacent metal surfaces. Another aim was to cut down the expense of passer boys commonly necessary in relaying the rivets to their destinations; and a further desire was to make it practicable to do all the rivet heating on deck or in the open air and thus to avoid locating rivet forges in more or less closed compartments where the gas might affect the workers.

In developing his equipment, Mr. Furman employed rubber hose at the start for conduits through which to blow his rivets from the forge to the riveting gangs. But this type of conveyer proved unsatisfactory, because it wore out rapidly and would burn through whenever a hot rivet became lodged in a bent section of the hose. This situation was corrected when metallic flexible hose was substituted. The manufacturers of this commodity, so it seems, promptly produced a special hose for rivet passing, and sizes are now available for the handling of rivets ranging from ¾ inch to an inch. For example, hose having an inside diameter of 1⅜ inches is furnished for the passing of ¾-inch rivets; hose having an internal diameter of 1 11/16 inches is made to take care of ⅞-inch rivets; and 2-inch hose is to be had for 1-inch rivets.



The compressed air rivet gun in its latest form. The rivet heater is just dropping a glowing rivet into the rivet-gun head to be shot to the rivet gang, below in the hull, 50 or more feet away.



A—Air inlet to compressed air tank.
B—Balanced check valve which allows rivet to drop into the pneumatic passer.
C—Connection for flexible metallic hose by which the rivet is blown to the rivet gang.
D—Treadle which releases a blast of compressed air for the propulsion of the hot rivet through the hose.

The pneumatic rivet passers now in service at the Chester yard of the Sun Shipbuilding Company are operated with air at a pressure of from 80 to 85 pounds per square inch; and experience has shown that these machines are capable of sending rivets through three lengths of hose, that is 150 feet, quite satisfactorily. The hose may run around corners and have several bends in it between the pneumatic passer and the discharge end, and yet the rivets will be sped onward to their destination without a hitch. All the heater has to do is to drop a rivet upon a balanced check valve, which allows the rivet to fall into the admission end of the hose; then, by pressing upon a pedal, a blast of compressed air is released from the passer reservoir; and the impulse of this released air serves to blow the rivet quickly to the farther end of the hose. Incidentally, the expansion of the air tends to cool the hose and to prevent it from becoming troublesomely hot.

The foregoing description covers broadly both the pneumatic rivet passers now in use at the Sun Shipbuilding Company's plant as well as a modified apparatus known as the "Penflex Rivet Gun," which is being manufactured and marketed by the Pennsylvania Flexible Metallic Tubing Company. A longitudinal section of the latter machine is shown herewith. For the sake of those who may be interested in details, the Penflex apparatus consists of a galvanized metal tank about ⅛ inch thick; and a ¾-inch pipe-thread inlet connection is welded to the side of this reservoir so that the air supply line can be coupled to it.

The gun is equipped with an operating lever placed at the bottom of the air tank; and this lever controls the discharge valve which is normally seated by a spring against a hard-rubber seat carried in the top of the tank. The valve is opened by the movement of a steel rod attached to the treadle. At the discharge end of the conveyer tube there is attached a metal rivet receiver. This receptacle is provided with a buffer block, supported by a buffer spring, which prevents the plastic rivet from being deformed when suddenly arrested upon reaching the end of its run. The weight of the Penflex gun is about 68 pounds; and its overall height is substantially 36 inches.

What these rivet guns can do is well exemplified in the following account of fifteen weeks of service in an important shipyard. Let us quote: "On new construction work the gun was used for passing rivets to riveters. Approximately 20,000 rivets were passed by the rivet gun to the torpedo-defense bulkheads and the boiler-room bulkheads, and about 8,000 rivets were passed to the double-bottom compartments and to the tank tops and shell. On alteration and repair work, the gun was placed on the main deck and was used for passing rivets two decks below and to very inaccessible locations. When used for this work, it was

possible to eliminate all passer boys—four boys ordinarily would have been required on this job. By using the rivet gun, the rivet gang consisted of only the heater boy, the riveter, and the holder-on: the rivets being passed directly to the holder-on who did not find it difficult to carry the receiver from hole to hole or to attract the attention of the heater boy by calling through the flexible tube for rivets as they were required.

"A test was also conducted for passing rivets overhead, and it was found that rivets could be passed satisfactorily to a height of 91 feet, the average time required for delivering rivets to this height being two seconds. The rivets were delivered with sufficient velocity to indicate that they could be successfully passed still higher, that is, to a height of 125 feet."

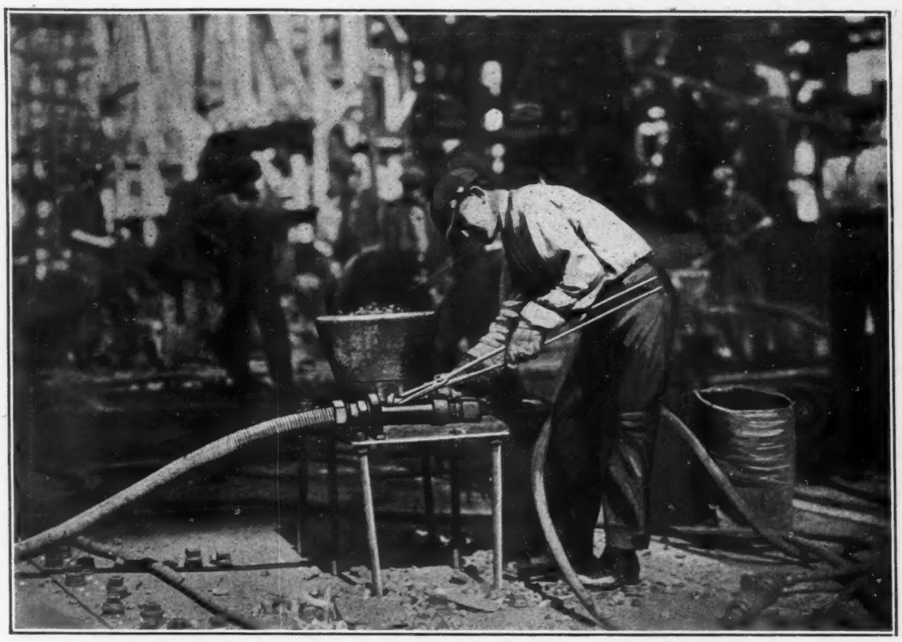
During laboratory trials to determine the air consumption of the rivet gun working under various conditions considerable data was obtained; and the accompanying table has been compiled therefrom. The figures, which cover a single rivet, are based on the mean air consumption for passing 100 rivets, and are corrected to cubic feet of free air per rivet at an absolute pressure of 14.7 pounds per square inch. It is believed that the air consumption in actual service will be found slightly higher because the laboratory trials were conducted under very favorable conditions. Even so, experience on the job has disclosed that rivets can be delivered very rapidly and with no perceptible loss of heat while in transit. Further, the rivet arrives at the receiver without scale owing to the fact that the scale is removed by the rivet striking the sides of the metal tubing during its journey.

It is authoritatively stated by a hull superintendent that the following advantages can be justly claimed for the pneumatic rivet passer: A saving in money; the elimination of passer boys; fires can be kept out of closed spaces, thus benefiting the riveting gangs as well as other trades working there; there are no ashes or waste coke lying around that may clog holes where the riveting is being done; and a rivet can be delivered and placed in a hole ready to drive in a much shorter time than that required when passer boys are employed, insuring a hotter rivet that is easier to drive and the doing of a better job, withal.

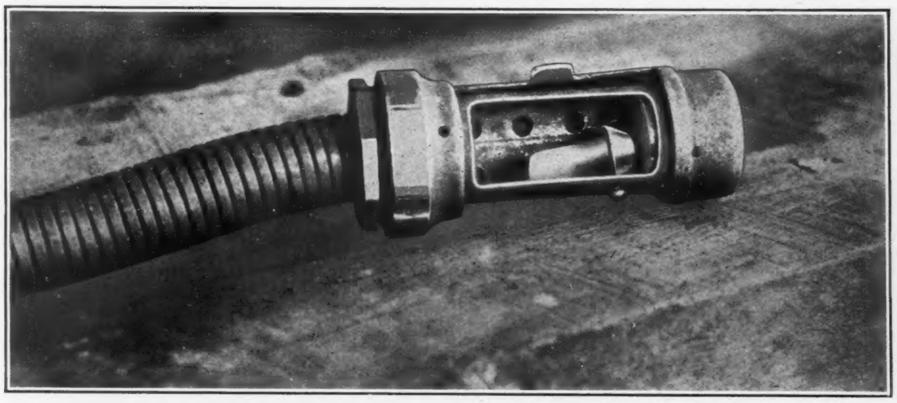
The high percentage of accidents incident to bridge building and other structural work by reason of faulty rivet passing is arousing the attention of the municipal authorities in many cities. Demands are being made for the reasonable safety of workmen as well as the public. The "catching can" should be a thing of the past; and the excuse that "one got away" does not satisfy when damage is done by a flying rivet.

Air Consumption Per Rivet

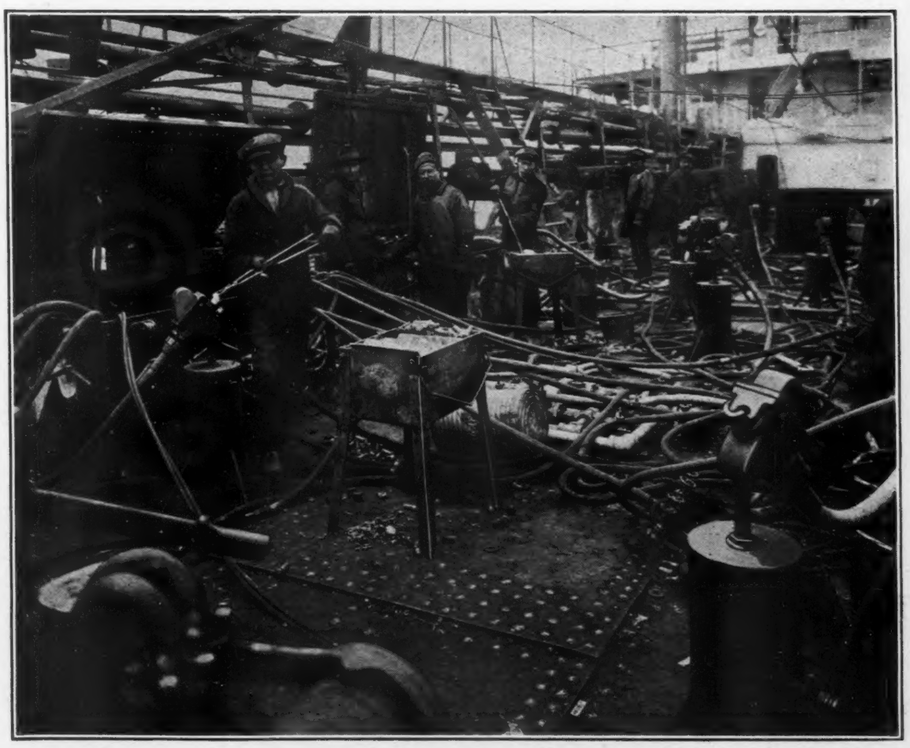
Size and type of rivet.	Travel 38 ft. Vertical, head first.	Travel 38 ft. Vertical, point first.	Travel 54 ft. Horizontal, straight line.	Travel 54 ft. Horizontal, Circular.
	cu.ft.	cu.ft.	cu.ft.	cu.ft.
⅞x2 in. countersunk	4.7	3.59	3.06	2.28
⅞x2 in. pan head	5.45	Would not pass	3.15	2.72
¾x1¾ countersunk	**2.85**	**3.12**	**2.0**	**1.7**
¾x1¾ in. pan head	**2.87**	**3.06**	**2.02**	**1.7**



The rivet gun in its original form as devised at the plant of the Sun Shipbuilding Company.



The discharge end of the Penflex rivet gun. A rotating cover seals this receptacle, and the rivet is stopped by a cushioning disc at the bottom of the receiver.



Pneumatic rivet passers in service aboard a vessel undergoing repair at the yard of the Sun Shipbuilding Company.

Compressed Air Magazine

—Founded 1896—

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EDITORIALS

THE TIDE HAS TURNED FOR THE RAILWAYS

PROBABLY nothing is a better index of the prosperity of the nation as a whole than the fact that business is picking up with a rush for our great trunk lines. The rising tide of traffic has inspired the pledging of more than $1,500,000,000 for new equipment so that the roads will be in a position to handle the flood of commodities which will be delivered for transportation in the early fall.

The railways are bent upon bringing their rolling stock to a state capable of moving efficiently the largest volume of traffic in the history of this country. So much has been said in the way of criticism of our great steam lines and their capacity to do their part properly, that it is not out of place here to cite some of the figures disclosed during the past month by the American Railway Association.

Let us quote: "In full realization of the necessity for the greatest improvement and expansion possible of the country's transportation facilities to meet the growing demands of commerce, the railroads have authorized since January 1, 1922, for cars, locomotives, trackage, and other facilities, the expenditure of $1,540,000,000, of which $440,000,000 was actually expended during the year 1922.

"From January 1, 1922, to March 15, 1923, the railroads purchased 223,616 new freight cars. Of these, 117,280 have been delivered and put in service. The railroads during that time also purchased 4,219 new locomotives. Of that number, 2,106 have already been placed in service."

It is further heartening to be told that the railroads are determined to push actively a program of road and building construction work during the open season of the current year, so that the backbones of these lines, the roadbeds, shall be fully equal to the tremendous burdens that are to be laid upon them when the output of farms, factories, mills, and workshops reach their maximum in the months to come.

A NEW FUEL SUPPLY

ACCORDING to CHARLES R. FETTKE, Associate Professor of Geology at the Carnegie Institute of Technology, Pittsburgh, Pa., the waning petroleum supply of the country may be supplemented to a great extent. The professor would take the enormous quantities of bituminous coal now being burned in the raw state for steam-raising purposes and for domestic uses and would subject them to low-temperature carbonization. This process, so we are told, will produce a fuel superior in many respects to raw coal; it will yield valuable by-products which will aid greatly in conserving the petroleum supply that is being rapidly depleted; and it will do much to abate if not to eliminate the smoke nuisance of cities.

Professor FETTKE repeats the warning that the unmined reserves of petroleum are being rapidly reduced, and points out that one of the problems that will have to be faced within the next decade or two will be to find substitutes, in continually growing measure, for the derivatives now obtained from petroleum.

The distillation of oils from shales, another promising source of fuel supply, will be restricted to those regions where an abundance of oil shale is readily obtainable. Where bituminous coal is found in larger quantities than shale it will be more economical to confine the business of procuring oil to the distillation of coal.

With the growing shortage of natural gas and anthracite, and the consequent increase in prices, other fuels of native origin must come more and more into use. One of these will, undoubtedly, be low-temperature coke. The low-temperature carbonization of coal, so the professor thinks, will be more advantageous than the distillation of oil shale. The coal so treated will yield, among other things, a residue that is valuable for fuel, while the spent shale is not only worthless but means must be provided for its disposal.

COPPER VERSUS GOLD

COPPER has come back with a rush. It is selling now at a higher price than any reached by it since September, 1920, and is nearly two cents above the average pre-war figure. The copper industry, which slumped along with other activities in the latter part of 1920, began to work itself up last fall. So rapid has been the "come back" that one of the largest refineries in the world has been laboring day and night, and spending hundreds of thousands of dollars, to put its plant in a position to take care of the business.

We are accustomed to think of gold as the most valuable metal in the world, with the exception perhaps of platinum. The two metals, it is true, possess one characteristic that sets them apart from other metals, and that is their immunity from tarnish or corrosion. Nevertheless, while gold is the accepted standard of monetary value, the metal itself has contributed almost nothing to man's advancement. From the standpoint of usefulness, gold is handicapped by excessive weight, softness, low tensile strength, high electrical resistance, and low heat conductivity. Even if unlimited and easily workable quantities of gold were to be discovered, the only effect would be to throw the world's financial machinery out of gear.

Aptly drawing a comparison between gold and copper, *Industry Illustrated*, on the other hand, says that there is hardly a field of human endeavor which would not benefit if we were to discover unlimited and easily workable supplies of copper. Without copper there could be no telephone, telegraph, or radio, and electro-pneumatic operations would be well-nigh impossible. Lacking copper there could be no bronze or brass; and electric lighting, electric motors, and large hydro-electric developments would be unprofitable.

If gold failed us, the world would have to readjust its financial system by the adoption of some other standard; but the march of industrial progress would in no way be interfered with. If copper failed us, however, civilization would have to halt in its onward career until some yet unknown substitute could be found.

THE THERMOS BOTTLE AS A MONUMENT

THE LIFE of Sir JAMES DEWAR, which came to a close recently, will long be an inspiring example to other workers in the realm of scientific research. But despite all that this eminent physicist accomplished in his chosen field of usefulness probably his name will be best known to the world at large because of what he did to blaze the way for the modern thermos bottle. In short, the thermos bottle, in its manifold applications, will be an enduring monument to his inventiveness.

It will be recalled that during 1891, Sir James constructed and exhibited at the Royal Institution in London an apparatus by which he was able to produce liquid oxygen in modest measures. That achievement was but one expression of his tireless labors in proving that many of the so-called "permanent gases" could, in fact, be liquefied by the application of sufficient pressure in conjunction with suitably lowered temperatures.

But the liquefaction of gases introduced another problem—that of discovering a type of vessel in which the gases could be stored so that their tendency to evaporate when they had been liquefied would be retarded. After much experimenting, DEWAR evolved a double container having an evacuated space between

the two associated receptacles. That is to say, he produced a nearly perfect vacuum between the outer and the inner combined vessel first, by exhausting the space as far as practicable with a vacuum pump and, then, through the curious action of pulverized charcoal held in a pocket inside that cavity. He discovered that charcoal, when chilled by the neighboring very frigid liquefied gas, had a strong affinity for any gases remaining in the partial vacuum; and by absorbing such gases the carbon helped to produce a higher vacuum.

By that one stroke of genius Sir James laid the foundation for the commercial or industrial transportation and use of liquefied gases, something that is yearly growing more and more in importance. Likewise, the DEWAR flask has made possible that exceedingly useful and convenient container, the thermos bottle, which is a source of comfort and satisfaction to millions of people. It is this latter comparatively commonplace or homely service that will endear DEWAR to mankind long after many of his other contributions to science have been generally forgotten.

SAVE HIGH BRIDGE

IT IS announced that High Bridge, which, as everyone knows, is an aqueduct that for three-quarters of a century has carried the Croton water supply of New York across the Harlem River, is to be pulled down, destroyed, wiped off the face of the earth. A monumental structure, picturesque and beautiful; a trophy of a most important epoch in the growth of the Metropolis; a bridge of an architectural and an engineering status comparable with the renowned erections of the ages is to be annihilated without adequate or compelling reason.

In fact, there is no reason at all for the destruction of the bridge or for the discussion which has been provoked. Of the fourteen arches which comprise the bridge only four are over the river; and the three supporting piers in the navigable channel that interfere with the active and the growing traffic must be removed. A single arch of not extravagant span would have entirely solved the problem of continuing the bridge; and it could have been designed, in fact has been designed, to harmonize with the existing structure so as to leave the bridge as satisfying to the eye and as complete in function as before.

The bridge cannot be pulled down, its material removed, and the surroundings returned to respectability without an appalling expenditure, and that would not be the end of it. The bridge has not become useless and superfluous for its original purpose. The conduit which it carries is still needed as an alternative branch of the water supply system; and in view of the talked-of removal it is planned to drive a tunnel under the river as a substitute at a great additional expense.

Besides retaining its normal aqueduct function, its monumental and practical value to the entire community, and its picturesque appeal to residents and visitors alike, the bridge might at little cost be made of greater value to the public than it is by finishing the top as a driveway with walks at the sides.

This is clearly a case in which there is much to lose and nothing to gain. The self-suggesting admonition is not merely to go slow in the matter but not to go at all, not to be rash or hasty in doing what cannot be undone when the loss is realized and the inevitable regrets develop.

It is humiliating to have to beg for the life of the old bridge, but we would do much more than that to save it. What interest any citizen can have in any other direction we are unable to imagine. R.

WHAT'S GOING ON IN THE BUSINESS WORLD

THERE IS no excuse, nowadays, for a business man to be behind the times for want of information as to what's going on in the world; and if he uses the information that is within his grasp he is always sure to be at least one lap ahead of his competitor who fails to take advantage of the opportunities offered.

Of late years, the principal banks of the country have taken it upon themselves to be the purveyors of information useful to the business man—information designed to assist in "taking the guess out of business." Each of the twelve Federal Reserve banks issues a monthly bulletin replete with interesting and useful information, and each reflects conditions in its particular section, be that from Boston to San Francisco, from Minneapolis to Dallas, etc.

These bulletins tell, by diagram and text, the story of the trend of wholesale and retail prices of commodities of all sorts; of banking and credit conditions; of the money and the security markets; of the export and the import trade and of foreign exchange; of the employment market and the trend of wages; of production, railroad earnings, business failures, chain and department store sales, etc., etc. A glance at these comprehensive publications, as they come along each month, reveals much that is invaluable to one who desires to be abreast of the times.

In the City of New York there are at least twenty banks, trust companies, and banking houses that regularly issue monthly or weekly letters in which every conceivable subject, bearing on commercial and political conditions both at home and abroad, is reviewed, analyzed, and explained. The economics of the different national and international situations as they arise are discussed by trained experts, and made clear to the layman.

Throughout the country exclusive of New York, and principally in the larger cities, there are 24 banks and banking houses, including four in Canada, which do the same thing. The information that is thus broadcasted is worth having, worth reading, and worth studying; and any and all of it may be had for the asking.

Anything savoring of a "tip" is studiously avoided by the writers of these bulletins. They do not attempt to tell their readers when to buy or when to sell. No careful student of the information so disseminated, however, can fail to be better qualified because of the knowledge thus acquired to cope with the competition that always surrounds trade.

For a busy man to read and to digest all of the information thus obtainable is out of the question. He hasn't the time to do it. But, recognizing its value, some of the large commercial houses employ a specially trained clerk to digest the data as it comes along; and he promptly places a short summary of it on the desks of the various officers and purchasing agents. In this way it is a comparatively simple matter for the busy executive to be abreast of the times and, possibly, ahead of his rival who does not "keep his ear to the ground."

OCEAN-GOING COLD STORAGE

MORE THAN a month back the first of the season's honeydew melons reached the Port of New York from South Africa; and in the same shipment were large quantities of peaches, grapes, pears, and plums from that far-off source of supply. Almost simultaneously numerous boxes of other fresh fruits were landed at the Metropolis from Argentina and Chile. From Cuba, Porto Rico, Mexico, and California—all by water routes, were delivered oranges, grapefruit, lemons, pineapples, and bananas.

These luscious foodstuffs could not have traveled the distances involved and arrived fit for use and capable of bringing goodly prices had not cold storage been employed to preserve them en route and to arrest harmful chemical changes. What has already been done by the aid of artificial refrigeration in bridging the climatic gap between widely scattered agricultural regions is merely a hint of what may yet come to pass when more and more cold-storage steamers plow their ways hither and thither upon the Seven Seas, carrying the plenty of one part of the world, that might otherwise go to waste, to consumers for the time being if not always less favored by Nature's abundance.

NOTES ON COMPRESSED AIR USED IN MINES

COMPRESSED air always provides material for discussion before the scientific societies, because, as Mr. D. H. CURRIER-BRIGGS, M. A., said in a paper read before the Midland Institute of Mining, Civil, and Mechanical Engineers, "it is as safe a means of providing power as can be adopted at the present time." Mr. CURRIER-BRIGGS dealt with many practical points with regard to the use of compressed air in mines, and described tests which he had carried out. He emphasized that while air compressors, themselves, if installed by a reliable and up-to-date maker, leave little for the colliery engineer to do beyond supervising and attending to ordinary running repairs, the receivers and pipe lines are a fruitful source of waste and trouble.

Where old boilers are used as air receivers, the heat can be extracted from the air by passing water through a cooling coil within the boiler, in which case the water carried in the air would be deposited in the bottom of the shell whence it can be exhausted through an

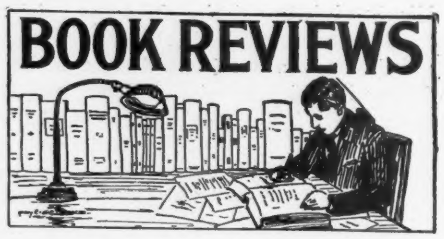
automatic trap. The absence of water in air mains is essential to the maintenance of good joints. The moisture can be extracted from the air by drawing it through trays of anhydrous chloride, which is a satisfactory dehydrating agent. The saturated calcium chloride, a compound that readily gives up its moisture at the reasonably low temperature of 130° C., can subsequently be dehydrated by passing superheated steam through tubes, laid in the trays, while leaving the tank or box open to the atmosphere. If air drying and aftercooling are resorted to, the air is in the best form for the transmission of power; and some portion of the heat, usually wasted, would be imparted to the water for boiler-feed purposes. Additional pumps would not be required, as the present feed pumps are capable of circulating the cooling water.

Water in the pipes and vibration make it difficult to keep air-pipe joints perfect; and receivers, having automatic water-extraction traps, should be fitted on all air mains. Pipes should be as large as feasible to reduce frictional losses. Mr. CURRIER-BRIGGS described tests, carried out by him, which showed the great losses due to pipe friction in small diameter pipes and even to small leaks. To reduce losses through pipe friction the main pipe should be as close to the working face as practicable, so that the small-diameter, flexible hose can be kept as short as possible.

Failure to maintain air motors in a proper state of repair is another important source of loss of compressed air. The engines continue to work satisfactorily to all outward appearances long after they should have been sent to the repair shop. The quantity of air wasted in this way would pay many times over the wages of the mechanics necessary to keep the air motors in proper condition. It is well to arrange for tests, to be carried out at regular intervals, that will assure the overhauling of air motors used underground as soon as they require it. R. H. B.

EDWARD J. FARRELL, retired construction engineer and tunnel builder, died February 13, at his home in New York City, aged 72 years. He was born in Capagne, New Brunswick, Canada, and was educated there. He was a member of the American Society of Civil Engineers. Some of his earlier construction work was on the Hoosack Tunnel, from North Adams to Springfield, Mass., and on the Lachine Canal in Canada. He also worked on the old Croton Aqueduct, the Lenox Avenue Subway, and on the Brooklyn Rapid Transit. The last big job in which Mr. Farrell was interested was the construction of the New York Speedway, along the Harlem River.

"It's what the user says that counts" is the title-page caption of Volume 18, issued by the Ever-Tyte Piston Ring Division of the Walter A. Zelnicker Supply Company, St. Louis, Mo. This pamphlet gives ample evidence of the varied services performed by piston rings and the importance of tight piston rings in many branches of industry.



THE BOOK OF RADIO, by Charles William Taussig, Associate Member, Institute of Radio Engineers. A volume of 447 pages, well illustrated, published by D. Appleton & Company, New York. Price $3.50.

HERE is a book that every radio "fan," of whatever age, may find well worth reading if not deserving of a place on his "wireless shelf." Radio telegraphy made an appeal to the amateur for some years before the World War; but this means of communication or "listening in" had a handicap because relatively few were willing to give the time and the study needful to master the Morse code and the abbreviated signals which have from time to time come to mean many things and much to the qualified radio dispatcher and receiver.

The development of radio telephony, which was urged to a practicable stage by military needs, left us as an aftermath of four years and more of strife in possession of a vocal means of communication of incalculable potentialities. At this moment, when radio broadcasting is a daily, yes hourly, occurrence, and receiving sets number many hundreds of thousands, still this whole art of sending afar through the ether the voice or instrumental music is only in its infancy. However, the accomplishments to date rest upon certain physical laws and electrical phenomena; and the more one knows about these the better able he is to understand his radio set and to get the best out of it.

The author has covered his subject comprehensively and with noteworthy clarity; and between the covers of his volume he has crowded a wealth of entertaining and informative material.

PATENTS AND TRADE-MARKS are the titles of two pamphlets distributed gratuitously by Messrs. Richards & Geier, 277 Broadway, New York City.

BOTH of these booklets are valuable to the man seeking information along these lines of proprietary protection; but the brochure dealing with trade-marks is of especial interest at this time. The trade-mark, like the good will of a going concern, is an asset which may be of much value in business. As has been well said: "Trade-marks to a manufacturer or a merchant represent something akin to that which the flag of a country represents to a loyal citizen. They are badges of honor, distinguishing marks, emblems to be proud of, to be kept above reproach and with a spotless reputation."

Unhappily, there has lately developed a disposition in other parts of the world to steal the trade-marks of American manufacturers, and the unscrupulous have not hesitated to put these pirated symbols of individuality and quality upon inferior goods and products and to offer them in competition with American manufactures of excellence entitled to carry those trade-marks.

The authors have done a patriotic work in presenting broadly the whole subject of trade-marks and in defining the legal limitations of protection in the United States and in foreign countries—making it plain what steps must be taken to foil piracy.

METALS AND THEIR ALLOYS, by Charles Vickers, specialist in melting, alloying, and casting metals. Also non-ferrous editor of Foundry and metallurgical editor of Brass World. An illustrated work of 767 pages, published by Henry Carey Baird & Company, Inc., New York. Price $7.50.

THE modern metallurgist achieves his wonders, meets the needs of wide and varied service, all because he has learned in the laboratory the possibilities of different alloys when combined with one or more metals. In other words, he is able to make a mix or composition which will have the physical properties suited to either common needs or to requirements of an exceptional character.

The book is in every sense a practical treatise even though it does deal with metals from their origin to their useful application. Similarly, no pains have been spared in describing the many alloys now employed and in making it clear what these substances can do in the way of imparting distinctive properties to the metal bases with which they are combined in varying degrees.

The owner, the manager, the metallurgist, the chemist, or the worker in the shop will each and all find in this volume helpful information that heretofore has been difficult to obtain.

JOURNAL OF THE IRON AND STEEL INSTITUTE, No. II, 1922, edited by George C. Lloyd, Secretary. Published by Spon & Chamberlain, New York.

The volume comprises the minutes of the proceedings at the autumn meeting of the Institute, held in the City of New York, September, 1922, together with reprints of papers presented on that occasion and the discussion and correspondence to which they gave rise.

IT IS impossible here to review the various papers which include, among others, An Investigation on the Factors Influencing the Grain and Bond in Molding Sands; The Nitrogenization of Iron and Steel by Sodium Nitrate; Practical Notes on the Manufacture and Treatment of High-Speed Steels; The Changes of Volume of Steels During Heat Treatment; and A Brinell Machine Attachment for Use with Small Specimens.

In our January issue of the current year we published an article entitled, *Safeguarding a Dam Against Harmful Ice Pressures.* We have since received a commendatory letter from the manager of the plant in question at Keokuk, Iowa, whose only regret was that we had seemingly not given credit to Stone & Webster, Inc., and more recognition to the Mississippi River Power Company for their joint labors in developing this unique system of ice protection. It gives us pleasure now to make due acknowledgment.

Efficiency in men is the power to do in the safest, shortest, and simplest way the most and the best.

The Problems of a Purchasing Agent are Manifold

Successful Buying of Raw Materials and Other Commodities is a Prime Part of the Efficient Management of a Modern Industry

By C. FRANK SCHWEP

THE desire to get the most for our money is born in us. Show me the man or woman who, after having made an advantageous purchase, is not proud of the accomplishment. The little child, that has just learned the value of money, takes its first penny to the candy shop and, after carefully surveying the display, selects twenty jelly beans in preference to a mint stick. When your wife comes home and shows you a saucepan marked down to 98 cents, or a coat that had been reduced $20.00 from the original price, she expects you to compliment her on her shrewdness in making these advantageous purchases. So we must agree that we are by nature ambitious to buy to good advantage or to drive a good bargain, which is nothing more or less than getting the most for our money or for what we give in exchange. But in carrying out this precept, we must have knowledge of the value of the article or commodity purchased, and this is why the procurement of materials has been segregated and specialized in our larger industries and institutions.

When you stop to consider that all the money represented in a manufactured product is paid out for either labor or material, you will understand why it is just as important to obtain the right kind of materials at the right prices as it is to employ the proper kind of workmen at a satisfactory wage. Every possible precaution is taken by the employer to safeguard his payroll expenditure: the employee is required to register his coming and his going so as to keep a record of his time and to account for any temporary absence from his post. In addition, he is under the continual supervision of his foreman and gang boss. All these measures are taken to insure the employer against paying his help for any service that is not performed.

Now, inasmuch as the expenditure for material in a finished article is an important element in its cost, sometimes even exceeding the labor factor, it is just as essential to take proper measures to procure the right kind of materials and to buy them at the right prices. Here is where the purchasing agent functions. Anybody can spend money; but, when it comes to the procurement of materials, it is quite another thing to spend money intelligently.

A capable purchasing agent is one who is familiar with the science of buying in all its phases. It is necessary for him to know practically as much about the commodity he is buying as the salesman who sells it. When it is remembered that the salesman of today usually has expert knowledge of the line of goods he is handling, you can better understand how difficult a task it is for the buyer to hold his end up with the seller.

The best source of information that a purchasing agent can have is the highly trained salesmen, and they are his best friends. Their familiarity with the merchandise they specialize in often enables them to give information as to market conditions in advance of any trade publications. The purchasing agent, therefore, instead of antagonizing the salesmen and treating them with contempt as is so often done, should cultivate their friendship if for no other reason than to profit by the knowledge they possess.

THE effective spending of money reaches into every walk of life and into all phases of commerce and industry. How to make the dollars buy their utmost is, therefore, a matter of well-nigh universal concern.

In the present article, the author, who is the purchasing agent of a large engineering enterprise, has outlined the responsibilities of the professional purchasing agent and reveals some of the fundamental principles governing the science of buying.

Of course, all salesmen are not competent. I have encountered salesmen that did not have enough ability to sell a sandwich to a hungry soldier; but, on the other hand, I have met some clever enough to sell Panama hats to Eskimos or telegraph poles to a wireless corporation. In these days of keen competition it has been found necessary to employ trained men who, after a thorough course of instruction and close observation, qualify themselves to represent the concern that has gone to the trouble and the expense to educate them. This higher type of salesman, with expert knowledge, is needed in dealing with the trained purchasing agent. Intelligent buying has been elevated to a science owing to the fact that selling has been specialized: and the purchasing agent who does not make use of the fund of knowledge broadcasted by the salesman will soon find himself at a disadvantage.

In order to buy intelligently it is necessary to have a thorough knowledge of each commodity or article purchased. In the case of raw materials, the purchasing agent should know where these are produced or mined, because the locality sometimes determines the grade, brand, or quality. Besides, the transportation charges, which are invariably an important factor in the cost, must be considered. When conversion or refining takes place, the process or method employed often has a direct bearing on the quality, and may also affect the cost on a comparable basis.

To the trained buyer, pig iron, steel, copper, spelter, tin, coal, coke, etc., are only identifying terms applied to these commodities. Each is classified according to grade, commercial value, or analysis. The chemical analysis, however, does not always tell the whole story; but this information, in conjunction with the physical characteristics and the process by which the commodity is produced, enables the quality to be fairly gaged. For instance, suppose the purchase of steel is under consideration. Then the analysis as well as the physical properties will guide in making a selection for a certain purpose. Again, steel may be produced by the open hearth or the Bessemer process, or by melting in an electric furnace or crucible, without showing much variation in the composition of the metal, and yet the cost of producing by the different processes may vary considerably.

Another example is coal. You may be able to buy bituminous coal from one district for $1.50 per ton and be asked $4.00 for coal mined in another locality. While the mining cost may not be the same, it would hardly account for the marked difference in the prices. The explanation is that the cheaper coal is the more abundant, of lower grade, and not comparable in quality with the higher-priced fuel. Generally the ash and sulphur content of coal determines its grade; and as the more expensive fuel is of better grade, is scarcer, and is more eagerly sought, it brings a higher price.

In selecting a fuel to give the best results, price should not be the first consideration. The higher-priced coal may prove the cheaper in the end for, regardless of the other determining factors, the most economical fuel is the one which evaporates a given amount of water at the lowest cost. And we must remember that the freight charges on a carload of poor coal are the same as on a carload of high-grade coal. Furthermore, the freight is sometimes higher than the cost of the coal, itself. In short, the first important step in purchasing is the selection of the proper materials for the purpose intended.

The same argument applies when buying tools, supplies, or other finished or partly finished articles. You must know the product offered. The manufacturing process employed, the character or quality of material entering into its manufacture, make for a good or inferior product. Do not let the price influence you until the merits of the article have been established. You cannot buy intelligently unless you know how the article is made, what it is made of, the approximate cost of manufacturing, and have some idea of its intrinsic value and its market value.

The best way to acquire this knowledge is to make a careful study of everything that you buy. Visit the factory where it is made and observe the various processes of manufacture from the raw materials up to the finished product. Such an education is invaluable to the salesman as well as to the buyer. Let me illustrate this point. Some years ago a salesman called on me—one of the blustering kind new to the game—and showed me a piece of hose with the remark: "What do you think of that?" I examined it, smelled it, chewed it, twisted it, stretched it, and then, looking at the salesman in a surprised way, said: "Why it appears to be made of reclaimed rubber entirely." He replied: "Yep, every bit of it." I then told him that I was afraid we were not interested.

On another occasion, a salesman offered Stillson wrenches much below the market price. When he was asked whether they were made of drop forgings or castings he didn't know, and was obliged to get the information from his factory. Needless to say, the wrenches were made of malleable castings, although they were polished and burnished and made to look like something good.

It is not necessary to tell you where to buy, because the purchasing directories and trade publications can do that to perfection. The carefully prepared indexes and advertisements enable the buyer to find just what he wants among a score or more of manufacturers and dealers. Be careful, however, to deal with only reputable houses. Half of your trouble will be avoided by steering clear of the irresponsible kind.

In any well-organized purchasing department there will be found a carefully compiled list of concerns to whom to apply for any commodity or article that might be required. These firms have been tried and tested, and can be relied upon for fair and square dealing. Make friends with the houses you patronize, and remember that your contact with them can build up a feeling of good will that will be an invaluable asset in the settlement of any differences that might arise. The purchasing department is constantly in touch with the outside commercial world, so it devolves upon it to maintain the ideals, the reputation, and traditions of the firm of which it is a part.

It is difficult to lay down any set rules for purchasing. "How to buy" is an art that cannot be taught. It must be learned by practice. Proficiency depends upon experience, judgment, and intuition. So many factors enter into purchasing problems that only by elimination can we find the elements that carry weight.

The selling price of a commodity or finished article is established by the producer or seller, or this may be done by an association of interests, based on the production cost and additional items. This price may be influenced by the season of the year, weather conditions, demand, competition, labor situation, speculation and manipulation, taxes, transportation charges, profiteering tendencies, margin of profits, etc. All or some of these things have their effect in determining market values. This being the case, the buyer, in order to justify what is a fair market value or selling price, must try to find out what is a fair cost or how much profit the seller is demanding.

Ordinarily, competition settles this question, but sometimes it does not. Speculating with the materials market is just as dangerous as speculating with the stock market. When prices are low it is safer to buy farther ahead than when prices are high, but having a high-priced market no conservative buyer will invest heavily with the expectation of prices going still higher.

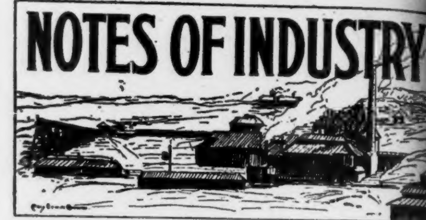
Whenever possible it is advisable to buy in large quantities in order to take advantage of the lower production costs; but where this is not desirable, deliveries can be spread over a given period by making time contracts. Every purchase has to be made on its own merits after all the facts in hand are carefully analyzed. The experience, judgment, and foresight of the buyer must be relied upon to show results. Intelligent buying is the keynote of good buying.

While there are doubtless other contributing factors responsible for the high prices with which we have been afflicted for some time, we cannot point to a more substantial reason for inflated values than what is implied by "unintelligent buying." When prices are mounting for no justifiable reason, then it is well to apply the brakes. Keep in mind, however, even after you hear the squeak of the arresting brakes, that the momentum gained will carry you forward until you come to a dead stop. Be prepared at that moment to make a fresh start on low gear, and be careful to accelerate your speed gradually.

Permanent investments to yield satisfactory returns are made only when conditions are favorable. You have to acknowledge that the man who has been clever enough to make money is usually endowed with enough intelligence to know when to spend it. He will not make an investment under abnormal conditions and run the risk of having the props knocked out from under him by something which had not previously entered into his calculations.

Results are what we are all after, and these are the measure by which success or failure is judged. We may be conscientious and do what we think is our best, but, even so, it may be possible to do still better. A little story will illustrate this point.

A certain purchasing agent, who made a practice of purchasing copper in 5,000 and 10,000-pound lots every week or two, conceived the idea of buying copper in carload lots, so as to save his company money. He made a careful investigation of the market and, after satisfying himself that prices had an upward tendency, he bought a carload of copper. Between the date of placing the order and the time the copper was shipped the price advanced about $700 on the quantity purchased. Being reasonably elated, the purchasing agent took occasion to inform his employer of what this foresight had accomplished, expecting, of course, to win commendation. Instead, his chief promptly asked: "Why under the sun didn't you buy two carloads?"



Aviators of the air mail service dropped bag of food into the Pacific Gold Mine & Millin Company's camp, American Fork Canyon Utah, where heavy snows had cut off the min foreman and a miner and family, who ha been on short rations for weeks. The snow-bound group could not have been reached i any other way.

At Zack, in the Ozark region of Arkansas, a mammoth cavern called "Blowing Cave," from which a current of cold air constantly issues has been fitted up as a storage warehouse fo fruits and vegetables, and has been used large ly by apple growers. More than a quarter o a mile of space has been fitted up with bin The main corridor of the cavern is 100 fe wide, and cold air comes through it from subterranean passage.

The first importation of marble from Guat mala, and for that matter from Central Ame ica, was made last November, when 437 cub feet were shipped from Puerto Barrios to Ne York. It is claimed that the stone is on a p with, if not superior to, Carrara marble, ina much as it is harder, more enduring, non-a sorbent, and without sand holes or flint.

If all the water power available in Austri were exploited, Austria's coal demand of abou 15,000,000 tons a year would be decreased t about 8,000,000 tons.

Mechanical ingenuity has apparently reache its limit in the manufacture of lace. Hand made lace is now so perfectly reproduced b machinery as to puzzle the experts, and th machines are said to be so contrived as t purposely introduce apparent faults which ad to the difficulty of detection. Old lacemaker in France are becoming destitute; and as scheme for their protection it is proposed t require a conspicuous label upon the machine made product.

We should be grateful to any of our reader if they would send to the editorial office, 1 Broadway, New York City, copies of the July October, November, or December, 1922, issue of COMPRESSED AIR MAGAZINE for which the have no further use.

It has been reported that the Souther Pacific Company of Mexico has arranged t construct 102 miles of track south of Tepic t Quemada, to connect with the railroad at Sa Pedro de Macoris, Guadalajara. Heavy engi neering work, including the construction of 3 tunnels, will be involved; and the cost of th undertaking is estimated at $12,000,000.

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